The Engineer

LONDON, FRIDAY, MAY 23, 1941.

PUBLIC NOTICES

CROWN AGENTS FOR THE COLONIES

ENGINEER

Required by the Government of Sierra Leone, Public Works Department, for one tour of 12-24 months. Fixed salary between £600 and £700 a year, according to qualifications and experience. Free passages and quarters. Candidates, not over 45, must be fully qualified Civil Engineers, able to Undertake the Design and Supervision of Construction of Buildings, Bridges, &c., Preparation of Detailed Plans and Estimates, and Taking-off of Quantities.

Write, stating age and full particulars of qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, MILLBANK, LONDON, S.W.1, quoting M/9552. 7434

INDIAN ARMY ORDNANCE CORPS

COMMISSIONED ORDNANCE MECHANICAL ENGINEERS

The India Office Invites APPLICATIONS for APPOINTMENT for duration of war as COMMISSIONED ORDNANCE MECHANICAL ENGINEERS in the Indian Army Ordnance Corps from qualified Mechanical or Automobile Engineers with definite Shop Experience in senior supervisory posts. Applicants should be British subjects between the ages of 23 and 40.

Initial pay in India will be Rs. 600 per month unmarried, Rs. 685 married, and if aged over 34, Rs. 765 unmarried and Rs. 900 married. Free conveyance to and from India. Short particulars of qualifications and experience should be sent in writing to the SECRETARY, MILITARY DEPARTMENT, INDIA OFFICE, S.W.1. Application forms and full particulars will be sent only to those prima facie suitable. Final applications should reach India Office by 30th June, 1941.

APPLICATIONS FROM CANDIDATES WHO HAVE PREVIOUSLY APPLIED SINCE THE 1ST DECEMBER, 1940, AND HAVE NOT BEEN SELECTED FOR APPOINTMENT, CANNOT BE ENTERTAINED. 7431

THE RIVER GREAT OUSE CATCHMENT BOARD

ASSISTANT ENGINEER REQUIRED

Assistant Engineer Required having a good general Mechanical and Structural Engineering experience, particularly with regard to the Preparation of Specifications, Lay-outs, and Installation of Pumping Machinery, and some knowledge of Survey.

Applicants should possess their own car, for which an allowance will be made in accordance with the Board's standing regulations. Commencing salary, £350 per annum.

For application form and particulars of duties, apply to the undersigned.

W. E. DORAN,
Engineer to the Board.

"Elmhurst,"
Brooklands Avenue,
Cambridge. 7435

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

TO ADVERTISERS UNDER BOX NUMBERS IN SITUATIONS OPEN SECTION.

For the benefit of applicants, the Proprietors are prepared to insert brief notices that vacancies are filled, upon receipt of notifications from the Advertisers. These notices (limited to one line) will be free of charge, and co-operation is asked for.

IMPORTANT

Advertisers in Situations Open Column should make themselves acquainted with the terms of

STATUTORY RULES & ORDERS 1940 No. 877

RESTRICTION ON ENGAGEMENT ORDER

WANTED, ASSISTANT WORKS MANAGER for factory in S.W. London manufacturing Light Mechanical and Electrical Devices, mainly Radio Communications. Permanent position with first-class concern for suitable applicant.—Please apply with full particulars as to age, qualifications, and salary required. Box 53 L.P.E., 110, St. Martin's Lane, London, W.C.2. 7444 A

WANTED, MACHINE SHOP SUPERINTENDENT for Engineering Works in S.W. England; man with experience in up-to-date Methods of Manufacture and Knowledge of Labour Relations given first consideration.—Write, giving age, experience, and salary required, 7429, The Engineer Office. 7429 A

WANTED, MACHINE SHOP SUPERINTENDENT for Engineering Works in S.W. England; man with experience in up-to-date Methods of Manufacture and Knowledge of Labour Relations given first consideration.—Write, giving age, experience, and salary required, 7429, The Engineer Office. 7429 A

CHIEF ENGINEER, Age 35 to 40, Familiar with Machine Shop Construction, Production and Costs, &c., with ability to link up practical production with sales and general policy. Unique opportunity of advancement offered to rising young engineer of right type. Short particulars only in the first place.—Address, 7390, The Engineer Office. 7390 A

CHIEF METHODS ENGINEER REQUIRED for diversified Engineering Works in the South of England. Candidates must have had wide experience in both Heavy and Light Machinery and be capable of Administrative Duties on Tool Design and Tool-making. Only those having at least ten years' experience need apply.—Please write, giving your experience, age, and the salary you have been accustomed to receiving, 7442, The Engineer Office. 7442 A

The Engineer

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PAPER ECONOMY

It has now become necessary, in order to maintain the normal circulation of THE ENGINEER, to print all advertisement pages on the Thin Paper hitherto used for the Foreign Edition.

So long as our diminishing stocks of thick paper will allow, the Home Edition Editorial pages will be printed on the usual paper, so that uniformity in bound volumes may be maintained.

SITUATIONS OPEN

GENERAL MANAGER, Structural and General Engineering Works, employing 100 men; state experience and salary.—Address, P3304, The Engineer Office. P3304 A

PRODUCTION or WORKS MANAGER, with extensive knowledge of Production Control, Labour, Bonus, &c. Capable of mass production of parts and tools. Young and energetic. Able to stand up to wartime pressure. Post-war prospects. Applicants kindly state age, education, career and salary.—Address, 7405, The Engineer Office. 7405 A

THE Post You Are Seeking May Not be Advertised in this Column, but do not lose the Opportunity of Bringing Your Requirements before all those who would be interested and could employ you. An Advertisement in the "Situations Wanted" Column would be seen by all Leading Engineering Concerns for a cost of Four Lines, 4s.; 1s. for each Additional Line. There is no better way of covering so large a field for such a small charge.

HEAD FOREMAN for Aero-engine Overhaul and Repairs. Congenial position with scope for advancement offered to a man with good experience of Radials.—Address, stating age, training experience, qualifications, and salary required, P3277, The Engineer Office. P3277 A

SITUATIONS WANTED

ADVERTISER is Desirous of Obtaining a FINANCIAL INTEREST in a small progressive Engineering or Machine Tool Business.—Send full particulars, which will be treated in the strictest confidence, to ENGINEER, 23, Springfield, Clapton, London, E.5. P3284 B

A.M.I. MECH. E. (43), Good Knowledge Design and construction of industrial gear drives, all classes of rope and electric cable machinery maintenance, &c., DESIRES EXECUTIVE POSITION.—Address, P3297, The Engineer Office. P3297 B

ASST. ENGINEER REQUIRES POSITION, Age 32 years; 5½ years' asst. works engineer, 5 years tech. asst. and resident engineer, London consulting engineers, on factory building.—Address, P3286, The Engineer Office. P3286 B

DESIGNING, DETAILING, TRACING UNDERTAKEN. Accurate calculations and neat drawings at moderate charges.—Address, P3281, The Engineer Office. P3281 B

ENGINEER, with Experience as General Manager, SEEKS ADMINISTRATIVE POST. Good technical and commercial record.—Address, P3294, The Engineer Office. P3294 B

SITUATIONS WANTED

DESIGNER, A.M.I.M.E., 20 Years' Experience on chemical and by-product plants with leading firm (hydraulic and electrical experience), at present chief engineer with small firm, SOUND POSITION WANTED, free; age 42.—Address, P3302, The Engineer Office. P3302 B

ENGINEER, 30 Years' First-class Experience, including apprenticeship, machine and fitting shop supervision, rate-fixing, works cost accountancy, and planning. Products covered include machine tools, light and heavy press tools, general heavy engineering, automobiles, aero-engines, and aircraft components. POSITION WANTED as WORKS MANAGER or PRODUCTION ENGINEER. Salary £650 to £700. Replies in confidence.—Address, P3300, The Engineer Office. P3300 B

GENERAL MANAGER or Similar Position REQUIRED by ENGINEER, A.M.I. Mech. E., A.M.I.A.E.; 34 years' comprehensive experience, mechanical, automobile, aeronautical; key positions held, chief draughtsman, chief inspector, chief engineer, works manager, welfare superintendent, sales and buying experience; useful business connection, England, Scotland, N. Ireland; well versed Government contracts; valid reasons for seeking change.—Address, P3299, The Engineer Office. P3299 B

HIGHLY EXPERIENCED MECHANICAL DRAUGHTSMEN (Scottish area) REQUIRE PART-TIME WORK: details, arrangements, tracings, &c., from sketches, originals, or specifications; strictest secrecy.—Address, P3301, The Engineer Office. P3301 B

IF the Man You Are Seeking is Not Amongst those Advertising in this Column, a Small Announcement in the "Situations Open" Column will Quickly and Economically Produce the Right Selection of Applicants, at the same time Eliminating Waste of Effort, Waste of Time, and Waste of Opportunity. The charge is Four Lines or under, 4s.; each Additional Line, 1s.; Box Numbers, 6d. extra, which includes despatch of all replies.

MANAGER and CHIEF ENGINEER (41 Years), with drive and proved organising ability, DESIRES CHANGE. Familiar with all classes of machine shop construction from foundations to production, planning, lay-outs, staffing, and production. First-class knowledge of mechanical and electrical engineering, controlling at present 1500 workmen. Expert on labour problems. At liberty end of June.—Address, P3293, The Engineer Office. P3293 B

MANAGER (43) Eleven Years' Full Control, manufacture and sales, of works making specialised metallurgical product with annual turnover of £90,000, SEEKS ADMINISTRATIVE POST.—Address, P3307, The Engineer Office. P3307 B

MECHANICAL ENGINEER, FREE, 30 Years' experience, well up with internal combustion engine production; last post assistant production manager; member F.M.B.—Address, 7445, The Engineer Office. 7445 B

MECH. and ELECT. ENGINEER (40), Several years abroad, dredging, mining, public works, chemical plant, &c., shortly completing large contract, REQUIRES POST, home or abroad.—Address, P3291, The Engineer Office. P3291 B

MECHANICAL ENGINEER, Age 37, Fully qualified, DESIRES RESPONSIBLE POSITION where initiative and energy could be fully utilised; present position designer and research engineer; wide engineering and commercial experience; London district preferred.—Address, P3298, The Engineer Office. P3298 B

POSITION REQUIRED by Mechanical Engineer, G.I. Mech. E., 3 years' works training, general engineering, 18 months mech. D.O., 2 years as m/c shop superintendent, small repetition work.—Address, P3303, The Engineer Office. P3303 B

TWO HIGHLY SKILLED BROTHERS REQUIRE POSITIONS of Managing Nature. Preferably together. Free to go anywhere. Age 29, matriculation, good knowledge of mathematics and sciences, experienced in works organisation, labour supervising, time and motion study, rate-fixing, progressing, estimating (graphs, statistics, index cards), practical experience of designing, engineering, welding processes, research. Age 26, technician for refined mechanics and instruments, able to take charge of drawing-office, experienced in jig, tool, and press tool design, design of optical and mechanical instruments, systematical experimenting and developing, specialist for standardisation and automatic checking systems, precision worker on light machine tools.—Address, P3296, The Engineer Office. P3296 B

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CLASSIFIED ADVERTISEMENTS CLOSE FOR

PRESS—NOON WEDNESDAYS

The Engineer
Annual Subscription Rates
(including postal charges).

BRITISH ISLES	£3	5	0	
CANADA	£3	3	0	Thick Paper Ed.
	£2	18	6	Thin Paper Ed.
ABROAD	£3	7	6	Thick Paper Ed.
(except Canada)	£3	3	0	Thin Paper Ed.

"THE METALLURGIST."

This Supplement, which deals with the Science and Practice of Metallurgy, both ferrous and non-ferrous, is published free with the last issue of THE ENGINEER each alternate month. Next date, June 27th.

ADVERTISEMENTS.

The charges for Classified Advertisements are 1/- per line up to one inch—minimum charge 4/-; those occupying one inch or more at the rate of 12/- per inch. Orders must be accompanied by a remittance. The rates for Displayed Advertisements will be forwarded on application. Classified Advertisements cannot be inserted unless delivered before TWO o'clock on Wednesday afternoon.

Letters relating to the Advertisement and the Publishing Departments of the Paper are to be addressed to the Publisher, all other letters are to be addressed to the Editor of THE ENGINEER.

Postal Address,
28, Essex Street, Strand, London, W.C.2.

Teleg. Address,
"Engineer Newspaper, Estrand, London."
Tel., Central 6565 (10 lines).

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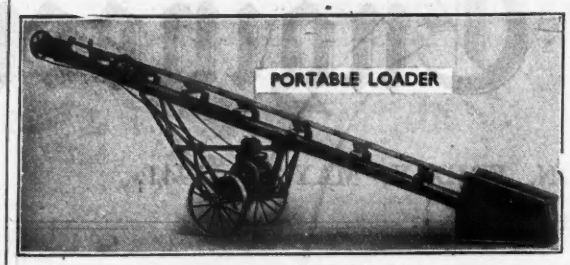
FOR EVERY PURPOSE.
J. & H. McLAREN, LTD., LEEDS, 10.

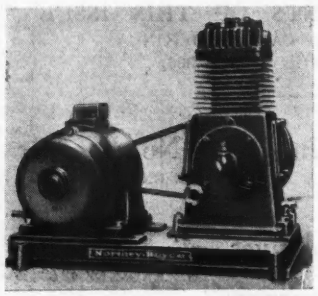
Manufacturers' Catalogues.

"The Engineer" will be glad to receive catalogues, lists of manufacturers' trade names, etc., from firms for inclusion in the files of the Enquiry Department.



CONVEYOR SPECIALISTS SINCE 1906

GEO. ROBSON & CO. HODGSON STREET — SHEFFIELD —



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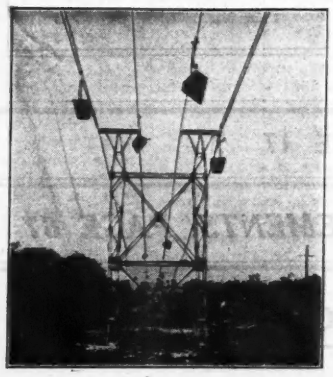

Telephone : Radlett 5900.
Telegrams : "Ropeways," Radlett.

An Example of OUR BICABLE ROPEWAYS.

Twin Lines, one carrying 100 TONS p. HOUR 3¾ MILES, the other 50 TONS p. HOUR 2½ MILES, near Sheffield.

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ENGINEERS & MANUFACTURERS OF
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Registered Office & Works:
South Benwell, Newcastle-on-Tyne.

SPRINGS
OF ALL TYPES
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PARK HOUSE WORKS, SHEFFIELD

L.E.H. *hydraulic machinery*
THE LEEDS ENGINEERING AND HYDRAULIC CO.LTD. RODLEY, LEEDS.

The Classified Advertisement Section is usefully employed by

MECHANICAL, CIVIL and ELECTRICAL ENGINEERS.

FACTORY and WORKS MANAGERS.

SALES MANAGERS, BUYERS, MANUFACTURERS and MACHINERY DEALERS.

AUCTIONEERS, ESTATE AGENTS and SOLICITORS.

GOVERNMENT DEPARTMENTS.

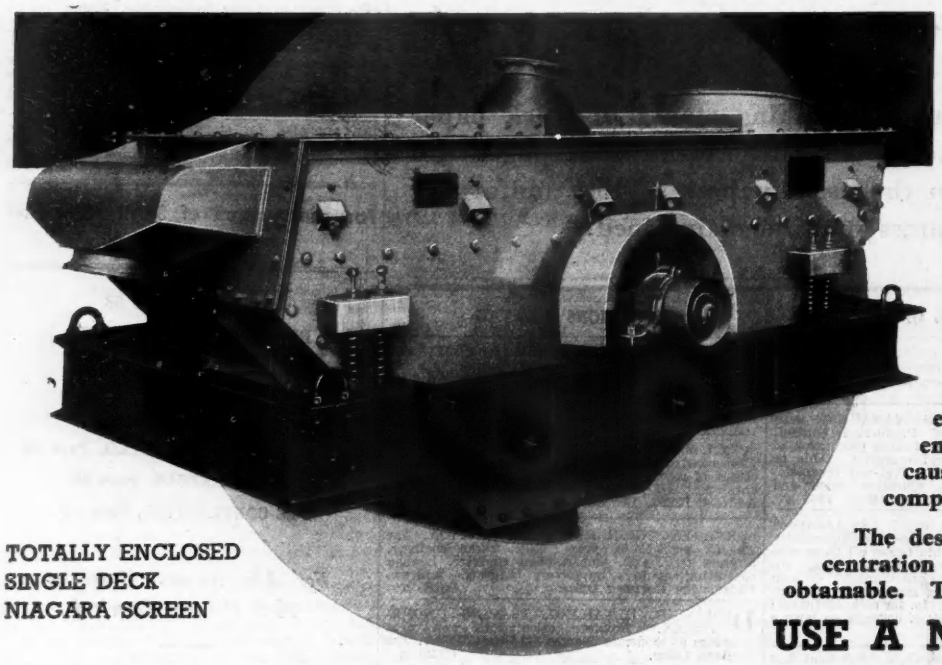
MUNICIPALITIES, PUBLIC CORPORATIONS and TECHNICAL SCHOOLS.

DIRECTORS and PRINCIPALS IN LARGE ENGINEERING CONCERNS.

AT HOME AND ABROAD.

"THE ENGINEER" classified advertisement section offers the surest means of bringing your announcement to the notice of a public anxious to take advantage of any opportunity which you have to offer.

Classified Advertisement Department
"The Engineer,"
28, Essex Street, Strand, W.C. 2.



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NIAGARA

The high standard of all-round efficiency which has popularised the NIAGARA Screen is due to the combination of approved engineering principles, first-class workmanship, materials of the best quality and a thorough understanding of the duty and conditions under which the machine must operate continuously.

In designing high-speed Vibratory Screens a complete knowledge of the various stresses developed is essential. Whilst controlled vibration can be usefully employed for many purposes, excessive vibration causes destruction. The Niagara does not embody complications or parts of special construction.

The design of the NIAGARA Screen is the result of concentration upon the highest possible efficiency of grading obtainable. Therefore

USE A NIAGARA FOR SCREENING

NIAGARA SCREENS (Great Britain) Ltd. Straysfield Works, Clay Hill, Enfield, Mx.

A Seven-Day Journal

The Late Sir David Owen

IN our issue of August 9th, 1940, we recorded the decision of the Government of Hong Kong to invite Sir David Owen to visit Hong Kong, along with Mr. Duncan Kennedy, M. Inst. C.E., as advising engineer, to inquire into the whole question of the harbour facilities, organisation and administration. It is with deep regret that we learn of the death of Sir David at Chicago, on Saturday, May 17th, while returning from Hong Kong to London. Sir David, who was sixty-seven years of age, was born in Liverpool, and he received his education at the Liverpool Institute. He served a business apprenticeship with the Mersey Docks and Harbour Board and afterwards joined the milling firm of Paul Brothers, of Liverpool and Birkenhead, as manager and secretary. In 1908 he took up an appointment as assistant manager to the Goole Docks, becoming manager seven years later. His next appointment was that of general manager and secretary to the Commissioners of the Port of Belfast. In 1922 Sir David became the general manager of the Port of London Authority, a position in which he served with distinction and from which he retired three years ago. During his term of office he inspired and assisted in carrying out, in collaboration with Mr. Asa Binns, M. Inst. C.E., M.I. Mech. E., many important schemes of port improvement and development. He visited many parts of the world in order to obtain first-hand knowledge of port administration and new developments. He was the author of many papers and communications on port construction and management, and he contributed from his wide experience in port administration to the volume on "The Origin and Development of the Ports of the United Kingdom," which appeared in 1939. He was a Past-President of the Institute of Transport, and Chairman of the Merchant Shipping Reserve Advisory Committee set up by the Board of Trade. His work for the nation was recognised in 1931 when he was knighted.

Railway Wages

ON Friday, May 16th, it was officially announced that the Railway Staff National Tribunal had considered the claims presented by the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen and the Railway Clerks' Association that the existing special war advances be increased as from November 25th, 1940, by 10s. per week in the case of adult male wages staff and by £26 per annum in the case of adult male clerical, supervisory and other salaried staff, with proportionate increases for females and juniors. The public hearing by the Tribunal of the latest claim outlined above was, it may be recalled, opened in London on Tuesday, May 6th, and was concluded the next day. The evidence tendered by the companies showed that the estimated total annual cost of the claims to the railway companies was put at £12,403,000, and the aggregate annual direct and indirect cost, after including consequential increases, at £16,759,000. The estimated annual cost of the additional war advances previously granted since June, 1940, is £11,954,000. The Tribunal made its award on Thursday, May 15th. The award provides that as from January 6th, 1941, the existing special war advances shall be increased by 4s. per week in the case of adult male wage staff, making a total war advance of 11s. per week, and by £10 per annum in the case of adult male clerical, supervisory and other salaried staff, making a total war advance of £28 per annum, with proportionate increases for females and juniors. More than 400,000 railway workers are affected by the award.

The American Battleship "Washington"

ON Thursday, May 15th, the United States Navy battleship "Washington" was commissioned, several months in advance of her scheduled time for completion. She was laid down at the Philadelphia Naval Yard on June 14th, 1938, and was thus completed and placed in commission in one month short of three years. According to "Jane," she was originally due for completion in October, 1942, but in course of her construction the work upon her hull and propelling machinery were speeded up. Like her sister ship, the "North Carolina," the completion of which on Wednesday, April 9th, was recorded in a Journal note of April 18th, she is considered to be one of the most powerful warships in the world. She has a length of 750ft., a beam of 108ft., and a mean draught of 36ft., her designed displacement being 35,000 tons. Her armament comprises nine 16in. guns, twenty 5in. 38-calibre double-purpose guns, with sixteen smaller guns. Four aircraft are carried with two launching catapults. According to unofficial figures, the armour at the sides has a thickness amidships of 16in., the upper deck being protected with 6in. armour and the lower deck with 4in. armour. The propelling machinery was designed and supplied by the Westinghouse Company, and it consists of a four-screw arrangement of geared turbines, taking steam from Babcock and Wilcox oil-fired boilers. The boilers, it is understood, are of new design, the steam conditions being 600 lb. working pressure with 400 deg. of superheat. The engine-room lay-out is carried out on a novel plan designed to save weight, and the preliminary drawings show the two funnels of the battleship abreast of each other. With the commissioning of the "North Carolina" and the "Washington," both of which were laid down under the 1936 naval programme, there remain to be completed four other battleships of the "Washington" class. They are the "Indiana," under construction at the Newport News Yard; the "Massachusetts," at the Quincy Yard of the Bethlehem Steel Corporation; the "Alabama," at the Norfolk Navy Yard; and the "South Dakota," at the yard of the New York Shipbuilding Corporation. These four ships were laid down under the 1938 programme, and were all launched during 1939 and 1940. They are scheduled for completion in 1943, but in view of the accelerated naval construction some may be completed at an earlier date.

Naval Construction Contracts

IN the remarks of the Comptroller and Auditor-General on the Navy Appropriation Account for the financial year ended March, 1940, now published as a Parliamentary Paper, it is stated that with the increased demand on shipyard capacity the normal method of allotting shipbuilding contracts by selection from competitive tenders became impracticable, and orders are now placed with selected shipbuilders known to have facilities available at the time, on the understanding that a fair and reasonable price will be fixed later. Instalment payments are meanwhile based on an estimated provisional price. Full information about the safeguards which will be applied by the Admiralty is not yet available, but according to the reports the Admiralty proposes to ascertain the actual costs of building a number of ships completed at fixed prices since the beginning of the war. Because of war conditions the Admiralty standard form of salvage agreement has been superseded by Lloyd's standard form of "no cure, no pay." The Treasury had asked the Admiralty to report in a year's time on its working. In a further section of the Account it is stated that the Treasury has delegated enlarged powers to the Admiralty in the matter of staff and works, so that it is not now obligatory for every smaller item in these spheres to receive Treasury approval before it may be acted on. A feature of this year's Account is a page of entries of gifts received in cash and kind in relief of naval expenditure.

Imperial Chemical Industries Limited

IN the report and accounts of Imperial Chemical Industries, Ltd., which are to be presented at the annual general meeting to be held in London on Thursday, May 29th, Lord McGowan states that in the home trade the war has been the source, direct or indirect, of ever-increasing requirements for nearly all the products of the company. In general, the factories at home worked to full capacity during the whole of 1940. The main manufacturing subsidiary or associated companies in the British Empire, Imperial Chemical Industries of Australia and New Zealand, Ltd., Canadian Industries, Ltd., and African Explosives and Industries, Ltd., continue to expand and to increase their manufacturing capacities. Lord McGowan says: These companies have also been of very material assistance to the company in its export trade, since in certain directions urgent needs at home interfered with the company's ability to supply from its own works and the overseas companies enabled it to maintain its markets by meeting the demand from their factories. The research in the company's laboratories during 1940 was largely directed to efforts to assist the better prosecution of the war. In addition to Service requirements, manufacture of products either to replace those previously imported or to supply new demands under wartime conditions and the development of new products for sale to export markets involved considerable research in devising processes to make use of available raw materials. The firm's agricultural research station was co-operating with the Government on various problems related to the increase of domestic food production, including the national silage campaign. Considerable progress was being made on a process for the production of feeding stuffs from straw for cattle.

Coalmining an Essential Work Industry

ON Monday, May 19th, the Minister of Labour and National Service, Mr. Ernest Bevin, announced the application of an Essential Work Order to the coalmining industry. The Order is to come into force as the particular undertakings are scheduled. Before any undertaking is scheduled, the Minister must be satisfied with the terms and conditions of employment and the welfare and training arrangements. In general, the new Order follows in principle those which have preceded it, in requiring the payment of a guaranteed wage. It contains disciplinary provisions for absenteeism, lateness, and failure to comply with lawful orders, and behaviour calculated to impede effective production. Under the Order it is necessary to obtain the permission of a national service officer before a workman can be discharged from or leave his appointment. Permission will always be given a workman to take up employment at another colliery, but only in exceptional circumstances will a man be allowed to leave the industry for other employment. Under the Order all engagements of labour for coalminining must be made through an employment exchange, or with the permission of a national service officer. The Order also incorporates the existing rule under the Undertakings (Restriction on Engagement) Order, 1940, which prohibits the engagement of men or boys normally engaged in coalmining or whose employment books bear the letters "S.A." for any other kind of work except through an employment exchange. The change comes into operation from June 9th. Following a conference at the Department of Mines on the proposed application of the Essential Work Order to the mining industry, the Executive Committee of the Mineworkers' Federation has decided to ask for a guaranteed minimum weekly wage of £4 throughout the industry. A meeting with the mineowners to discuss the claim has been arranged.

The Detection of Night Bombers

IN the course of a recent appeal by Mr. C. G. Power, the Canadian Minister for National Defence, for 2500 radio technicians for the Canadian Royal Air Force, he made reference to a new device which is being employed in the defence of Great Britain. It is understood that British scientists, in collaboration with research experts, both in Canada and America, have devised a new and powerful means of defence against day and night air attack. While details, he said, must remain secret, Mr. Power disclosed that in general terms the new device made use of a great number of small radio sets of modern design. By such means it was possible for radio technicians posted at ground points all over the British Isles to detect enemy aeroplanes in the air and to direct anti-aircraft fire with deadly precision. While great things were expected of this new invention by the Air Ministry, it called for men to make it work. For several months past, Mr. Power went on to say, Canada had been combed for amateur and professional radio men who had been despatched overseas to assist in this special work. According to a recent announcement, there are now more than 1000 Canadian radio mechanics already in England. The source of supply having dried up, Mr. Power appealed for 2500 further men. The authorities were, he said, ready to take green men, men of good education, even if they were unfamiliar with radio work. They would, he said, be trained in this new work, and would within a few months be holding key positions in the defence of Britain. In order to fill the urgent need, thirteen of the Canadian universities have promised their assistance. We may record that on Monday last a wireless appeal was made for young men over 16½ and under 18 for training as radio operators.

The Late Sir Thomas Williams

RAILWAY engineers will learn with regret of the death, on Monday, May 19th, at his home, "Oakdene," St. Margaret's-on-Thames, of Sir Thomas Williams, a director of the London Midland and Scottish Railway company. Sir Thomas, who was eighty-eight years of age, was engaged in railway work throughout his whole career. He joined the London and North-Western Railway Company in 1876 and received his early training in the South Wales district. In the succeeding years he occupied successively many important positions in various parts of the company's system, and in 1919 was called upon to succeed the late Sir Guy Calthrop as general manager of the company. In 1917 he was Chairman of the Goods Managers' Executive Conference, a member of the Canal Control Commission, and the Port and Transit Conference, which dealt with the traffic at the ports during the last war. In recognition of his many services he was knighted in 1919. Sir Thomas was selected by the Railway Executive Committee to give evidence on railways and canals before the Select Committee on Transport. For many years he took a keen interest in the continuation classes for the junior railway staff, which were held at Euston and in other large railway centres. Formerly he held the rank of Lieutenant-Colonel in the Engineer and Railway Staff Corps, R.E., T.F. He was a man of robust personality and had great force of character. Until quite recently he enjoyed good health, and no stranger would have suspected him of being the age he actually was.

Facts About the Rifle

By DAVID WEIR, B.Sc.

No. II

(*Continued from page 316, May 16th*)

Elevation and Range

NOW what about the amount by which a bullet falls during its flight? It is necessary to determine this amount accurately for all ranges, so that we may know how much to tilt the muzzle of the rifle up to compensate for it.

Let us consider one range, say, 600 yards.

From the curve of Fig. 4 we find that the Service bullet takes 1 sec. to travel 600 yards. The distance the bullet will fall vertically in that time

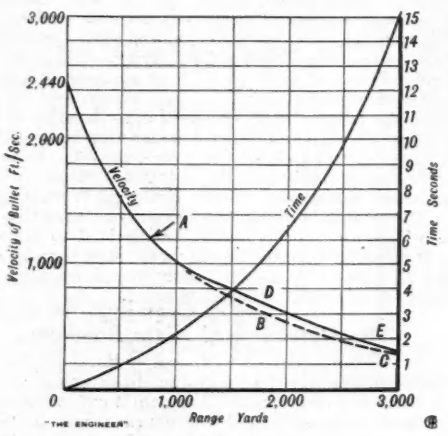


FIG. 4 (REPRODUCED)—VELOCITY OF BULLET IN FLIGHT

in vacuo is found from the well-known equation of motion

$$s = U t + \tfrac{1}{2} g t^2,$$
$$\text{or } s = \tfrac{1}{2} g t^2$$

when, as in this case U, the initial velocity downwards is nil. We have therefore $s = \frac{1}{2} \times 32{\cdot}2 \times 1^2 = 16{\cdot}1$ft.

But the bullet is not in vacuo, but in air, which presents considerable resistance to the bullet falling broadside on, with the result that instead of dropping 16·1ft., it falls only 13ft. (this has been established by actual range tests).

In other words, $g = 32{\cdot}2$ is much too high a value for g for a bullet falling in air. The value of g that would give the correct answer at 600 yards range is $g = 26$, for then $S = \frac{1}{2} g t^2$ would become $S = \frac{1}{2} \times 26 \times 1^2 = 13$ft.

This modified value of g is known as the "sophisticated value," and is referred to by the symbol f. It is an "apparent average value" over the range considered.

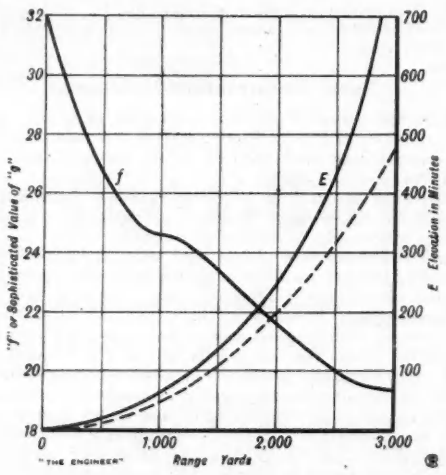
The values of f for various ranges are tabulated in the "Hythe Firings," and have been plotted in Fig. 6. Note the inflection in the curve about 1000 yards range, where the velocity of the bullet approaches the velocity of sound. It will be observed that f starts off at zero range with the value of 32·2 ft./sec.², and falls to the low value of 19·4 ft./sec.² at 3000 yards range. Obviously these values of f will only apply to the Service bullet fired with an initial velocity of 2440ft. per second. Any change in the weight, shape, or muzzle velocity of the bullet will alter the value of f.

Reverting to the fact that the bullet falls 13ft. in 600 yards:—

If one wishes to hit a bull's-eye, located in the same horizontal plane as the muzzle end of the rifle axis, it will be necessary to incline the muzzle end upwards so that the tangent of the angle which the line of the bullet makes with the horizontal is $\frac{13\text{ft.}}{600\text{ yards}}$, or 0·00717 (see Fig. 7), *i.e.*, an angle of 24·6 min.

This angle is known as the "elevation" for 600 yards range. Such angles for the S.M.L.E. rifle and Service ammunition are given in the "Hythe Firings," and have been incorporated as a curve in Fig. 6, full curve. The dotted curve gives the corresponding "elevations" for the U.S.A. Model '17 rifle.

Note that if one wishes to find the angle at which the axis of the rifle barrel (as distinct from the line of departure) must be inclined to the horizontal,



Full curves—S.M.L.E. Mk VII Ammunition
Dotted curve—U.S.A. Model '17 Rifle

FIG. 6—ELEVATION AND "SOPHISTICATED VALUE" OF GRAVITATIONAL ACCELERATION FOR VARIOUS RANGES

4½ min. (the negative "jump" of the S.M.L.E. rifle) must be added to the "elevation" angle at all ranges. In the case of the U.S.A. Model '17 rifle, about 6 min.[9] would have to be subtracted from the "elevation" angles, as the "jump" in that case is believed to be about 6 min. positive, *i.e.*, upwards.

It is an interesting experiment to measure the height of the backsight on a Service rifle at the various range settings, and to see how the angles deduced therefrom, after correction for "jump" and height of foresight (see below) check up with the curve of Fig. 6.

In determining the "elevation" angles recorded in the "Hythe Firings," special instruments of high accuracy were used. These measured the angle between the line of departure and the horizontal through the muzzle end of the barrel axis, precisely as shown in Fig. 7. When we come to use the rifle in actual practice, however, one cannot "sight" along the horizontal line shown in Fig. 7, as this would necessitate placing the foresight exactly in the centre of the muzzle, which is obviously impossible. In the case of Service rifles the foresight is usually placed about 1in. (2in. for telescopic sights) vertically above the axis; with most machine guns it is also necessary to move the foresight to the side to avoid certain fitments on the gun. The foresight is fixed and the appropriate inclination is given to the barrel by raising the backsight, so that the butt of the rifle has to be lowered a corresponding amount, when the sights are aligned horizontally on the target. In actual practice we therefore have the condition shown in Fig. 8.

From Fig. 8 it will be clear that if we used the appropriate "Elevation" from the "Hythe Firings" the bullet would not hit the bull B, as seen along the sights, but a point A below the bull, where A B equals the height of the foresight above the centre of the muzzle. The rifle must therefore be given slightly more "elevation" than recorded in the "Hythe Firings," in order to lift the point of impact from A to B. This amounts to approximately 1 min. increase at 100 yards in the case of the S.M.L.E. rifle with normal sights, and less in inverse proportion for longer ranges. The correction is therefore very small, and is allowed for in the calibration of the backsight scale. Note that when the foresight is moved to the side, as it is on most machine guns, the error introduced by this sideways movement can only be compensated for at one particular range, unless a non-vertical movement of the backsight is adopted. This is never done on small arms, as the error is very small.

A point of interest, though not of much practical consequence, will be noted from Fig. 8. As a result of raising the foresight above the barrel axis, the trajectory of the bullet crosses the line of sight at C as well as at B. This means that there are two ranges for which any particular setting of the sights is correct. As the "elevation" is reduced, the points C and B come closer together until at some very close range they become coincident, *i.e.*, when the line of sight is tangential to the trajectory of the bullet, as shown in Fig. 9.

In the case of the S.M.L.E. rifle this occurs at a range of 56 yards, with an "elevation" of 3·3 min. (U.S.A. '17, 64 yards, with 3·1 min.). Any reduction of the "elevation" below this value gives no definite range at all, for then the trajectory never crosses the line of sight.

When there is a "zero" calibration marked on the backsight scale of a rifle, this indicates the setting at which the line of departure of the bullet is dead parallel with the line of sight. Such a "zero" mark will be found on the Ross rifle. Note that the commonly used, but unfortunate, expression "zeroing a rifle" does not refer to the determination of the "zero" as defined above, but simply means checking the calibration of the sights by test shots on the range.

The "double crossing" of the line of sight is made use of in checking the accuracy of the sights. Instead of setting the test target at a point B (Fig. 8), it is usually fixed at C, where it can be seen more clearly; and where external influences such as wind will have less influence on the flight of the bullet.

Another point of interest is that if the "elevation" of a rifle, as made, is plotted against the range, we do not get a curve passing through the origin, as shown in Fig. 6, but a curve, as shown in Fig. 10, where a minimum value of elevation is reached, after which the curve rises again for lower ranges, and eventually becomes asymptotic to the Y axis. This means that for these lower ranges

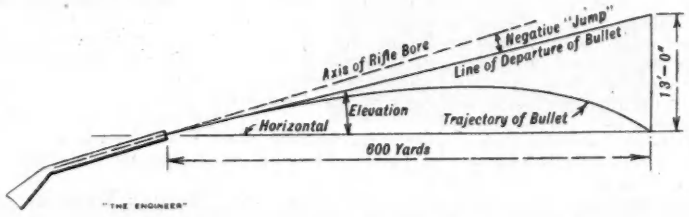


FIG. 7—ELEVATION AND TRAJECTORY

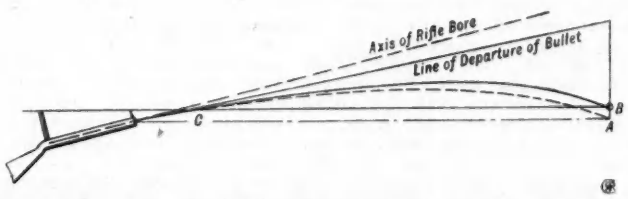


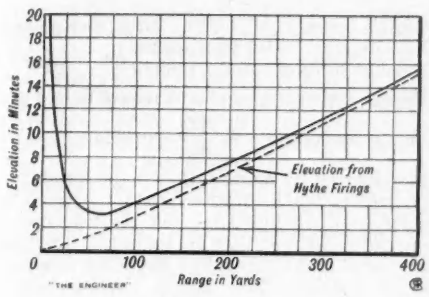
FIG. 8—EFFECT OF POSITION OF SIGHTS

FIG. 9

[9] It has been impossible to obtain an accurate figure for the "jump" of the U.S.A. Model '17 rifle.

we are using the "first crossing" of the line of sight instead of the "second crossing," as is done for the longer ranges.

The polar curves of Fig. 11 show the horizontal range and the maximum vertical height reached by the bullet for all angles of "elevation" from 0 deg. to 90 deg. The full curves are for the U.S.A. '17 rifle, for which complete data are published. The dotted curves for the S.M.L.E. rifle are approximate only. Both curves show that the



S.M.L.E. Rifle Mk VII Ammunition

FIG. 10—CURVE OF ELEVATION

maximum horizontal range occurs at an "elevation" in the neighbourhood of 33 deg., and not at the theoretical angle of 45 deg.

THE EFFECT OF WIND

Wind has a seriously disturbing effect on the direction of a bullet and a much smaller but appreciable effect on the range.

Up to ranges of ¾ mile, the lateral deflection due

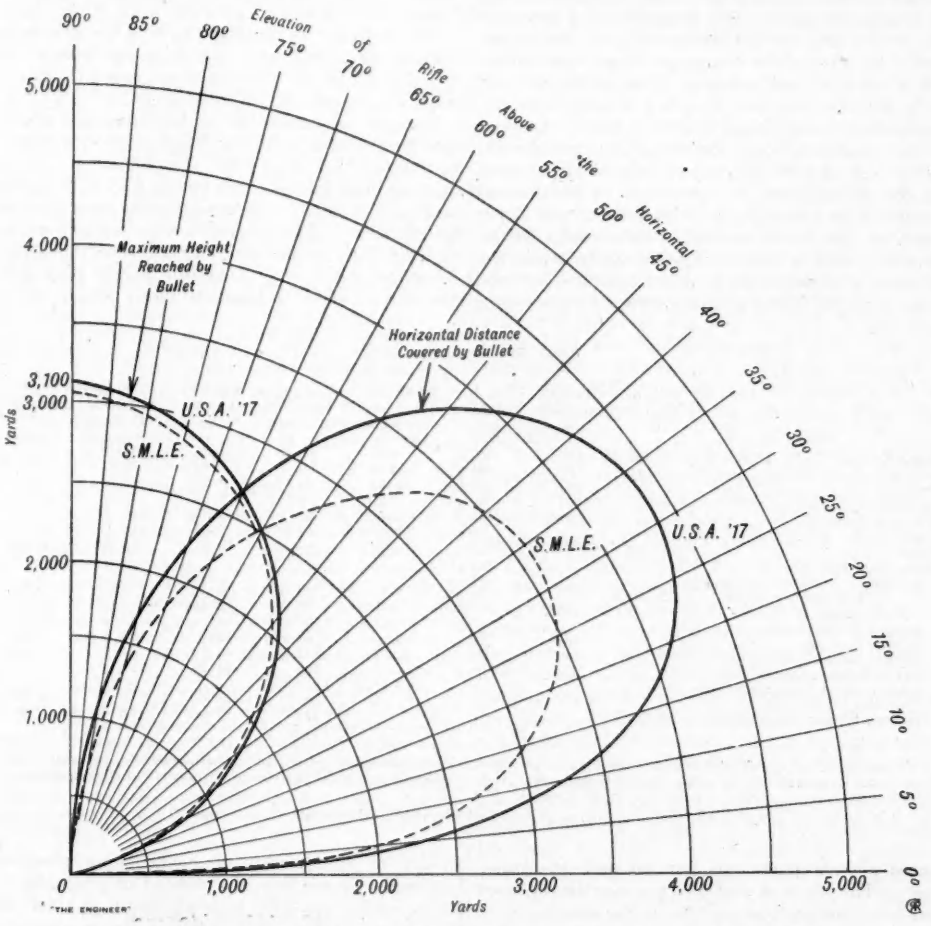


FIG. 11—HORIZONTAL RANGE AND MAXIMUM HEIGHT AT VARIOUS ELEVATIONS

to the wind in minutes of angle may be taken as proportional to—

(1) The horizontal speed of the wind at right angles to the flight of the bullet.

(2) The range.

(3) The "delay" of the bullet over the range. (By "delay" is meant the difference between the actual time taken by the bullet to traverse the range and the time it would take in a vacuum.)

Statement (1) is fairly obvious, as one would expect that doubling the velocity of the wind would push the bullet out to the side twice as much over a given range, and this is equivalent to twice the angular deflection for the small angles involved.

Statement (2), however, is not so obvious, because one might think that if the range were doubled, the bullet would be pushed out twice the distance, which would mean no change in the angle of deflection. One would, however, be overlooking the fact that the bullet takes much longer to traverse the later parts of its path than the earlier parts, in consequence of which the wind is acting on the bullet for a much longer time during 100 yards of its flight towards the end of its travel than during 100 yards at the beginning of its flight. Actual range tests show that if the wind necessitates setting the sights 3 min. to the left at 300 yards range, they would have to be set 6 min. to the left at 600 yards. Over 600 yards strict proportionality is not sufficiently accurate for good marksmanship. In the above case 12 min. would be the adjustment at 1000 yards. In other words, the adjustment varies as the curve of Fig. 12, instead of as the straight line of strict proportionality.

Statement (3) is less obvious still, but it can readily be appreciated by considering the three cases (*a*), (*b*), and (*c*), as shown in Fig. 13.

(*a*) Firing from a train at a stationary target.

(*b*) Firing from the ground at a target on a train.

(*c*) Firing from a train at a target on another train.

Assume the muzzle velocity of the bullet in all cases to be 2400ft. per second, approximately that of the S.M.L.E. rifle, and the velocity of the train to be 40ft. per second (27·3 miles per hour); the range in all cases is 600 yards, or 1800ft.

From ballistic tables (or Fig. 4) we find that a Service bullet takes 1 sec. to travel 600 yards with this muzzle velocity, whereas in a vacuum it would take 1800/2400, or ¾ sec. only, *i.e.*, the "delay" in this case is ¼ sec.

In case (*a*) the bullet leaves at an inclination of $\frac{40}{2400}$ or one-sixtieth (*i.e.*, 1 in 60) to the line of sight; therefore it will hit the target one-sixtieth of 1800ft., or 30ft. to the left of the bull.

In the case (*b*) the bullet will obviously hit 40ft. to the right of the bull.

In case (*c*) the bullet will hit 40ft. right minus 30ft. left, or 10ft. right of the bull.

Now (*c*) is the case analogous to that of a cross wind with a velocity of 40ft. per second, and we see that the 10ft. error=40×¼, *i.e.*, velocity of wind×"delay" time.

The reasoning used in this specific example is of general application, and establishes the truth of statements (1) and (3) above.

The formula commonly used by marksmen for estimating the allowance to be made for wind is as follows:—

$$\text{Wind allowance, in minutes of angle} = \frac{\text{Strength factor} \times \text{direction factor} \times \text{range factor}}{10}$$

where the strength factor=gentle wind, 4 m.p.h.; moderate wind, 8 m.p.h.; fresh wind, 12 m.p.h.; strong wind, 16 m.p.h.; very strong wind, 20

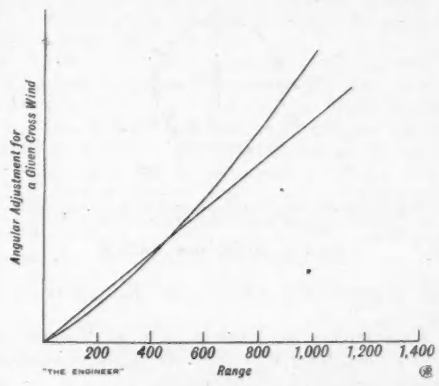


FIG. 12—ADJUSTMENT FOR CROSS WIND

m.p.h. The direction factor is as shown in Fig. 14, and the range factor=2 for 200 yards range; 3 for 300 yards, 4 for 400 yards, 5 for 500 yards, 6 for 600 yards, 8 for 700 yards, 9 for 800 yards, 11 for 900 yards, and 12 for 1000 yards range.

As mentioned above, wind has a slight effect on the range. Even with a strong head-on wind, the "elevation" has only to be increased by 50 yards (or 9·5 min.) at 1500 yards range. With a strong following wind the "elevation" should be reduced by 50 yards (or 14 min.) at 2000 yards range.

HIGH-ANGLE FIRE

All Service rifles are sighted for firing at a target in the same horizontal plane as the muzzle (or, more strictly, the foresight) of the rifle. Targets above or below this horizontal plane will make a difference to the "elevation" required. Obviously when firing vertically upwards no "elevation"

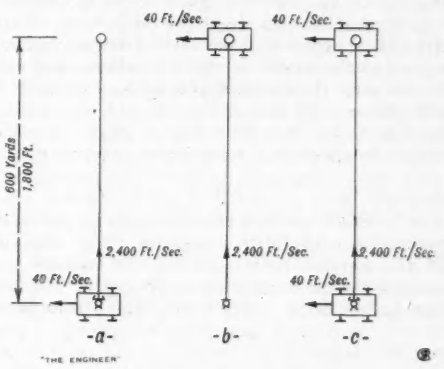


FIG. 13

at all is required for any range. The targets to be dealt with in normal service are, however, sufficiently near the horizontal to permit of this difference being ignored; but when firing at aircraft corrections must be made for the angular elevation of the target, if accurate shooting is to be achieved.

To give some idea of the magnitude of the correction necessary, here are some figures for the S.M.L.E. rifle:—

(1) With the target at a height of 30 deg. above the muzzle:—

Distance muzzle to target.	Sights should be set at	Equivalent to a reduction of the normal elevation of
1000 yards ...	950 yards ...	5·7 min. or 9·5 per cent.
1500 ,, ...	1425 ,, ...	13·5 min. or 10 ,,

(2) With the target at a height of 60 deg. above the muzzle:—

500 yards ...	350 yards ...	6 min. or 31½ per cent.
1000 ,, ...	700 ,, ...	28 min. or 46½ ,,
1500 ,, ...	1025 ,, ...	75 min. or 54 ,,

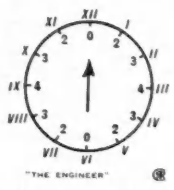
When the target is below the horizontal the "elevation" required is approximately the same as when the target is at the same angle above the horizontal—theoretically it should be slightly less.

SPIN

The fact that spinning a projectile gives it greater steadiness in flight seems to have been known from

primitive times, but the rifle (or hand gun) had been in use for a century before some unknown genius thought of giving spin to bullets by means of rifling the barrel of the gun. The idea appears to have originated with the armourers of Nuremberg. The difficulty in those early muzzle-loading days was to get the bullet rammed down the muzzle of the rifle, whilst leaving it a tight enough fit for the rifling to be effective. This difficulty disappeared, of course, with the introduction of the breech-loading rifle.

The spin of a bullet must be sufficient to keep it steady and head on during its flight, but too much



These numbers are roughly proportional to the sine of the angle which the wind makes with the direction of fire.

FIG. 14—DIRECTION FACTOR

spin is objectionable for reasons that will be given later.

Experiments have shown that for the modern bullet filled with lead (S.G. 10·9), a satisfactory amount of spin is given when

Length of bullet in calibres × length of one turn of rifling in calibres = 150 to 200.

In the case of the Service bullet, this gives

$$\frac{1{\cdot}28\text{in.}}{0{\cdot}303\text{in.}} \times \frac{10\text{in.}}{0{\cdot}303\text{in.}} = 140,$$

which seems to indicate that the Service bullet is overspun.

For bullets of metal other than lead, the spin should be varied inversely as the square root of the density. Thus an aluminium bullet, which is a quarter of the density of lead, would require double the spin.[10]

Spin has also to be varied directly as the square root of the density of the medium in which the bullet is travelling; for example, a bullet travelling through water, which is 900 times as heavy as air, would require thirty times the air spin to keep it stable.

For the first 50 or 100 yards after leaving the muzzle a rifle bullet is recovering from the initial disturbances due to the shock of discharge. During this period the bullet is liable to be a "tipper," *i.e.*, it may make a slightly oval hole in a card. After that, however, it has settled down to what is known as the steady or stable condition, but even in this state its centre of gravity may continue to describe a very fine helix. In the case of the Service bullet this helix has a length of about 5 yards and a diameter of approximately 0·01in.

DRIFT

As a direct result of the spinning of a bullet the phenomenon of "drift" appears. Take the case of the Service bullet leaving the muzzle with counter-clockwise rotation as viewed by the firer. The bullet, being pointed and being, in addition,

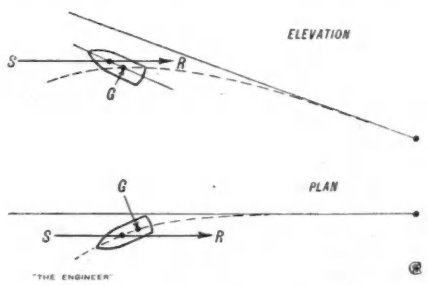


FIG. 15

provided with an aluminium nosepiece, has its centre of gravity behind the centre of air resistance.

Suppose the bullet has reached a point as shown in Fig. 15, where it is assumed that gravity has caused its axis to make an angle with the trajectory. It will be seen that the air resistance S R exerts a moment about the centre of gravity. If the bullet were not spinning, this moment would increase the angle which the bullet makes with the trajectory, but as the bullet has a high rate of spin, it behaves like a top, consequently the angle does not increase, but instead the moment causes the nose of the bullet to "precess" or rise out of the plane of the paper by gyroscopic action. This means that the nose moves over to the left, as seen in plan. The moment is still active, as shown, but now (in plan) it causes depression of the nose, then movement to the right, thus bringing the axis of the bullet tangential to the trajectory, when the moment disappears. In this semicircular precessional movement the air resistance has obviously a component pushing the bullet as a whole out towards the left. This gradual movement to the left away from the vertical plane of the trajectory is known as "drift." With right-handed spin the bullet would, of course, "drift" to the right.

In the case of the S.M.L.E. rifle and Service ammunition, the actual amount of drift is about 10in. at 1000 yards, or 1 min. of angle. At 1500 yards it is about 2 min., thereafter it increases rapidly until, according to one statement, it reaches 100 yards, or 100 min., at the extreme range of 3600 yards. Though this statement is made in an official publication, it is difficult to credit. It seems usual to fix the backsight 2 min. to the right, so that an average correction for drift may be given for all ranges up to 1 mile.

YAW

This is a phenomenon observed more or less with all guns at long ranges. When firing over large stretches of flat sand the hole made by the bullet in the sand at long range shows clearly that on impact the bullet has not been travelling with its spinning axis parallel to the tangent of the trajectory. Divergences of as much as 45 deg. are not uncommon. This angular divergence is termed "yaw." The cause of yaw is not fully known, but it is certainly gyroscopic in nature, and increases distinctly with the rate of bending of the trajectory. It is definitely connected with the fact that whilst the forward velocity of the bullet falls off very rapidly, the rate of spin falls very little by comparison (though not definitely known, the loss of spin is probably only 5 to 10 per cent. per second, as against a loss of forward velocity of 44 per cent. in the first second, 25 per cent. in the second second, 13 per cent. in the third second, and 11 per cent. in the fourth second). This results in the bullet having a high rate of overspin when the trajectory is beginning to bend rapidly—just the time when the bullet requires to turn its nose down rapidly to keep its axis parallel with the trajectory. The effect of yaw is to increase the air resistance enormously and to shorten the range.

RECOIL

By Newton's third law the forward momentum of the bullet plus air and the products of combustion is equal to the backward momentum of the gun, provided, of course, that the gun has complete freedom of movement.

Extensive experiments have shown that the weight of the products of combustion plus the air forcibly blown forward by the muzzle blast ("ejecta"), is equivalent to from one to two times the weight of the explosive charge. The average value of $1\frac{1}{2}$ times is usually assumed in calculations.

Hence we have :—

Weight of gun × Velocity of recoil = (Weight of bullet + $1\frac{1}{2}$ × Weight of charge) × muzzle velocity.

For the S.M.L.E. rifle this becomes :—

$$8{\cdot}656\text{ lb.} \times \text{Velocity of recoil} = \left[\frac{174\text{ grains}}{7000} + 1\tfrac{1}{2} \times \frac{37{\cdot}5\text{ grains}}{7000}\right] \times 2440\text{ft. per second.}$$

$$= 80{\cdot}28\text{ lb.-feet per second, units of momentum.}$$

$$\therefore \text{Velocity of recoil} = 9{\cdot}27\text{ft. per second.}$$

$$\text{Energy of recoil } \frac{M\,V^2}{2\,g} = 11{\cdot}56\text{ foot-pounds.}$$

(Compare energy of bullet, 2298 foot-pounds; ditto + "ejecta," 3042 foot-pounds.)

Average force of recoil = 1560 lb.[11]

Distance travelled by gun (if free to move) when bullet clears muzzle $= \frac{11{\cdot}56\text{ft.}}{1560} = 0{\cdot}09\text{in.}$

It is interesting to note that if the weight of a given rifle is doubled the momentum of recoil and the force will be unaltered, but the velocity and energy of recoil will both be halved.[12] The backward travel of the gun before the bullet leaves will also be halved. This largely explains why a machine gun (which fires Service ammunition) has a very weak recoil as compared with the Service rifle. The Bren gun weighs about 2·6 times the Service rifle, the Lewis gun about 3·1 times, and the Hotchkiss gun 3·2 times. In addition, the acceleration of the mechanism backwards (for ejection and reloading) by part of the explosive gases helps to reduce the recoil still further. Finally, the tripod or bipod stand adds further to the weight and helps to take what little recoil is left. There seems to be some reaction from the supporting stand, which, coupled with the vibration of the gun mechanism gives the firer the impression that the gun is tending to run away from him. Machine gunners will state quite definitely that it is necessary to hold the gun back when firing. This may be a false impression, for it is difficult to see how the recoil, small though it may be, can actually become negative.

It should be noted that we have assumed above that the gun has complete freedom of movement. In practice we know that this is not so, as the rifleman must hold the gun firmly, and at the same time pull it back with considerable force against his shoulder. If he does not, bitter experience in the form of a bruised shoulder will soon teach him otherwise. A loosely held rifle comes back and hits the shoulder a hammer blow, which is the result of the energy of recoil being absorbed suddenly by the shoulder instead of gradually, as it is when the rifle is held firmly against the shoulder. Quite apart, however, from avoidance of this hammer blow effect, it should be appreciated that the holding of the rifle rigidly against the shoulder is equivalent to adding part of the

Recoil Data for Various Rifles

	Weight of gun, lb.	Weight of bullet, grains.	Weight of charge, grains.	Muzzle velocity, ft. per sec.	Momentum of recoil, lb.-ft./sec.	Velocity of recoil, ft./sec.	Energy of recoil, ft./lb.	$\sqrt{\text{Energy}}$.
Great Britain	8·656	174	37·5	2440	80·3	9·27	11·6	3·4
France	9·187	197·6	46·3	2380	90·7	9·90	14·0	3·74
Germany	9·875	154·2	49·5	2882	94·0	9·52	13·9	3·73
Switzerland	10·0	174	49·3	2720	96·3	9·63	14·4	3·79
U.S.A. Springfield	8·5	150	50·5	2600	83·7	9·87	12·85	3·59
U.S.A. Model '17...	9·0	150	50·0	2700	84·0	9·34	12·2	3·5
Austria	8·344	244	42·3	2034	89·3	10·7	14·8	3·85
Other hand guns :—								
Webley Service revolver (0·455), with one shot ..	2·385	265	5·5	600	23·4	8·33	3·57	1·89
Fully loaded...	2·632	265	5·5	600	23·4	8·90	3·24	1·80
Special Webley pistol					50·0	15·0	12·0	3·47
12 bore shot gun	6·5	464†	33	1240	98·0	15·1	23·0	4·80
Normal big game rifle (0·470)	10·5	490	80	2200	191·7	18·26	54·3	7·37
Large elephant gun (0·600) ...	15	900	110	2000	304	20·26	96	9·8
Experimental anti-tank rifle (0·500)	18				285	16·0	70	8·36*
Ditto, with anti-recoil silencer	20				212	11·0	35	5·9

* Note that the recoil of this gun is too high to permit of it being fired frequently from the shoulder without anti-recoil devices. Even with the so-called "anti-recoil silencer," the recoil is still too high, and the gun is normally fitted in addition with a heavy recoil spring to soften the shock of recoil.

† Total weight of No. 6 shot load, to which must be added the weight of the wads, *i.e.*, 40 grains.

[10] Yet we find, in the volume previously referred to, cheek by jowl with this inverse square root law, a statement to the effect that an S.M.L.E. rifle will fire correctly the cupro-nickel jacket of a Service bullet from which the lead has been melted, since the extra spin necessary in that case is so small as to be negligible.

[11] This is obtained from :—

Force × distance bullet travels in barrel = kinetic energy of (bullet + "ejecta"). Now distance from base of bullet in chamber to muzzle = 23·44in., or 1·95ft. Therefore force $= \frac{3042}{1{\cdot}95} = 1560$ lb. This checks up fairly closely, after allowing for friction, with the average pressure (9·8 tons per square inch) of the curve in Fig. 2.

[12] Note that that half of the original energy of recoil, that, due to the increased weight of the rifle, no longer goes into recoil, must now go into the bullet (since the total energy in the explosive charge is constant). It follows therefore that the muzzle velocity of the bullet must be increased. The amount of this increase is, however, negligible, for even if all the energy of recoil were transferred to the bullet it would only increase the energy of the bullet from 2298 to 2309 foot-pounds and its velocity from 2440ft. to 2446ft. per second.

weight of the firer's body to the weight of the rifle. The more firmly the rifle is pulled backwards against the shoulder, the greater will be the amount of this added weight, and we have seen above that increase in rifle weight reduces both the energy and the velocity of recoil. It would not appear impossible to take actual measurements of the amount by which recoil energy can be reduced by rigid holding, but no record of such experiments can be found.

It seems that there is considerable doubt as to which of the above factors of recoil, or what combination of them, is a measure of the "sensation of recoil" or "kick," as it is commonly called. Some state that recoil energy alone is the criterion, and give a limit of 15 foot-pounds for a gun fired from the shoulder. It would appear, however, that it is some combination of mass of gun and velocity of recoil—but neither energy ($\frac{1}{2}$ M V^2) nor momentum (M V)—that determines whether recoil is bearable or not. Velocity seems the more important factor. Possibly the square root of the energy would be an approximate measure of the "kick," with an extreme limit of 5. It has long been accepted that with a shot gun weighing 6$\frac{1}{2}$ lb. a velocity of 15ft. per second must not be exceeded if "gun headache" is to be avoided.

When we speak of recoil being "bearable" we mean bearable under a continuous spell of firing, such as has to be maintained under active Service conditions. In the case of an elephant gun or other big game rifle, the "kick" may be "bearable" though nearly twice as severe as the limit indicated above, for the simple reason that one does not expect to fire such a weapon more than two or three times a day.

A comparison between the recoil data for the British Service rifle and those of some other nations is given in the table on page 332.

APPENDIX I

Armour-piercing Ammunition

Armour-piercing ammunition, having the same external dimensions as the Service ammunition, is made for the 0·303 rifle. A heavier charge is used to give the bullet a muzzle velocity of 2500ft. per second, with a maximum chamber pressure of 20·5 tons per square inch. The bullet has the same shape of nose as the Service bullet, but is 1·36in. long, instead of 1·28in. The diameter is 0·313in. (mean of tolerance), as against 0·311in., to compensate to some extent for the smaller "set up." The jacket is of steel, coated with cupro-nickel, and inside is another thin jacket or sheath of lead over the pointed hardened steel core, which measures 0·25in. in diameter. No information is given as to the total weight of the bullet, but it is probably much the same as the Service bullet.

The penetrating power depends almost entirely on the striking energy of the core alone. It will pierce 10 mm. or fully $\frac{3}{8}$in., of good-quality armour plate at 100 yards. The accuracy is poor, but this does not matter much, as this ammunition is of little use over 400 yards.

This ammunition is distinguished from the ordinary Service ammunition by having the annulus of the cap painted with a green varnish.

Tracer Ammunition

The "tracer" cartridge is also made to the same external dimensions as the Service cartridge. The bullet has a cupro-nickel jacket, a lead plug in the nose, and the space at the rear is filled with a composition of magnesium powder and barium peroxide. The bullet is open at the rear end so that the composition is ignited by the cordite charge and burns during flight, leaving a visible wake or "trace" behind it. In this way the path or trajectory of the bullet is made visible, so that the Service or armour-piercing bullets which follow it up in subsequent shots may be directed on to the target. The difficulty is to make the trajectory of the comparatively light tracer bullet—which gets lighter still during its flight—approximately the same as that of the "business" bullets which will follow it. This, however, has been achieved with reasonable accuracy up to a range of about 600 yards.

Tracer cartridges are distinguished from Service cartridges by having the annulus of the cap painted with a bright red varnish.

BOOKS RECEIVED

Civil Engineering Handbook. Second edition. Edited by L. C. Urquhart. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 35s.

Construction Planning and Plant. By A. J. Ackerman and C. H. Locher. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 28s.

General Engineering Handbook. Second edition. Edited by C. E. O'Rourke. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 28s.

Acceleration in Linkwork. By W. R. Thomson, B.Sc. Tech., A.M. Inst. C.E. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, W.C.2. Price 21s. net.

Engineering Mechanics. By S. Timoshenko and D. H. Young. Second edition. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 28s.

Cement Chemists' and Works Managers' Handbook. By W. Watson, B.Sc., and Q. L. Craddock, M.Sc. London: Concrete Publications, Ltd., 14, Dartmouth Street, S.W.1. Price 15s.

The Oil Situation in the Middle East*

By "OILFIELD ENGINEER"

WHEN considering the oil situation in the Middle East, especially in Irak, one has to depend very much upon newspaper reports. Comments with these reports inevitably refer loosely to oil, as if crude oil, produced in the various oilfields, were a commodity available for use immediately on the spot. Crude oil must be refined before it can be used, and the refineries in all parts of the Middle East are easily rendered completely useless, either by bombing from the air or by demolition by ground staffs. When this important point is appreciated properly, the situation loses much of its unfavourable aspect, and newspaper comment is shown, almost invariably, to be ill-informed and unduly alarming in character. To make use of the oil resources of the Middle East, even should the Nazis continue their conquering progress to Irak, Iran, Egypt, and Russia, the crude must be refined. With the refineries all destroyed, and the pipe lines irreparably damaged, the Axis Powers would have either to transport refinery equipment from Europe over a long and difficult route, to be erected in the actual oilfields, and thus provide fuel and lubricants for their forces and aircraft on the spot, or they would have to rebuild pipe lines and gain command of the Mediterranean, to transport the crude to European refineries, which may or may not be left standing after R.A.F. bombing attacks.

A glance at the sketch map will show the distances to be traversed for either alternative to be practicable. When it is remembered that the Nazis are hard put to it to repair their own refineries, owing to restricted output of refinery equipment in European countries, and that they lack the necessary huge output of line pipe for new pipe lines, the considerable and complicated equipment for laying pipe lines, and the experience on pipe line work, together with there being no possibility of obtaining the services of expert American pipe liners, any oil man who knows his job has the right to question the Axis strategy which, apparently, will cost great numbers of men and considerable effort to gain control of Middle East oilfields. These fields will produce crude oil, if drilling and producing equipment is available for the purpose, but they will not, owing to lack of refineries, make fuel and lubricants available to the Axis armed forces, either on the spot or in Europe.

Having made these important points clear, we may study the various areas in which crude oil is produced.

Irak.—Competent American sources estimate Irak crude production in 1940 to be around 10,000 tons per day. The majority of this production comes from the Kirkuk field, which is one of the largest producing areas in the world. This field is about 65 miles long by an average of about 2 miles wide, and approximately sixty wells have so far been drilled. Many of these wells are each good for a production of more than 10,000 tons per day, but for various reasons the output is restricted. The Kirkuk crude is around 36 gravity A.P.I.—a fairly good grade of crude, and is produced from formations at 2100ft. to 2200ft. One of the gratifying features of the Kirkuk field is that there is a very small pressure differential. Wells when flowing wide open for short periods on test, compared with those shut in, show a pressure of 13 lb. per square inch as against 20 lb. per square inch. Development of the field has been very scientific, and nearly all the present production is piped through the line from Kirkuk to Haifa. This line is bifurcated near the Syrian border, but after the collapse of France no crude went through to Tripolis on the Syrian coast, where a small refinery treated the small stocks of crude held in storage tanks there.

The restriction of pumping crude only to Haifa has caused a drop in total production.†

Before pumping the crude from Kirkuk to the refinery at Haifa, it has to be treated in a stabilisation plant, designed to remove the high content of hydrogen sulphide. This stabilisation plant—which is not a complete refinery—has a capacity of more than 10,000 tons per day, and the capacity of this plant, until the French defection, restricted the total crude volume pumped through to the Mediterranean.

The Haifa plant undoubtedly produces most of the fuel and lubricants required by our forces in the Mediterranean areas of Africa and Palestine. The success of the Nazis in Greece places the Haifa plant in a rather precarious position, however, as it is within range of bombers operating from the Greek air bases.

Should we be forced to evacuate Palestine as the result of a Nazi drive through Turkey or *viâ* the many islands of the Eastern Mediterranean, we may be sure that the Haifa refinery and the long stretches of the pipe line towards Kirkuk will be destroyed by our ground forces. But it must be remembered that the loss by bombing or enforced evacuation of the Haifa plant is not vital, as Egyptian refineries can supply considerable quantities of fuel and lubricants, whilst we have production of the Bahrein refinery, Burmah, Iranian, and even Dutch East Indies plants available, so long as we keep command of the Indian Ocean and of the Red Sea.

The former B.O.D. field at Qaiyarah, 75 miles south of Mosul, on the banks of the Tigris, has a potentially great production, but the crude oil is of poor quality, being less than 20 gravity A.P.I., with a content of more than 6 per cent. of sulphur. The Qaiyarah field is about 23 miles long by an average of 2$\frac{1}{2}$ miles wide, and about sixty wells have been drilled there. Production is very restricted, owing to the poor quality of the crude, and to the limited facilities of the Irak pipe line carrying the higher grade Kirkuk crude to Haifa. Production at Qaiyarah is estimated to be less than 13 tons per day, and this oil is used only for local fuel and road oil requirements. The oil is produced from the Asmari limestone, at depths of 700ft. to 1500ft.

Naft Khaneh, just over the border in Irak from Iran, was formerly in Persia until a new line of demarcation between these two countries was drawn after the last war. Production here is less than 60 tons per day, which includes production from the small field of Chia-Surkh. The oil from these two fields is piped to the refinery at Khanaquin (Aldwan), which has a capacity of about 360 tons per day.

The only other refinery in Irak is that at Baba Gurgur, with a capacity of slightly more than 200 tons per day. This plant treats crude from Kirkuk for local requirements.

This survey of Irak indicates quite clearly that although crude oil production is now restricted, the potential production is great. But the Irak crude could not be transported to European refineries for treatment, until complete command of the Mediterranean was obtained, and the time taken to lay new pipe lines or to repair the damaged line now operating would be so long, owing to the factors already detailed, that the Irak crude would be of no military value to the Axis, even if new drilling and producing plant were transported from Europe for resumption of production.

Egypt.—Egypt has not received much limelight from the point of view of oil. This country has, however, considerably increased exploratory activity during the past few years, with encouraging results. Again in 1940, production was increased by 50 per cent., and Hurghada and Ras Gharib are the two main producing fields. The crude has a gravity of 36 A.P.I. at Hurghada and of 38 A.P.I. at Ras Gharib. There is a large and a small refinery at Suez. These plants play an important part in the supply of refined products to our Near East forces. Ras Gharib is a field capable of greater production, and refinery capacity in Egypt will undoubtedly be increased in the future.

Iran.—The Anglo-Iranian Oil Company, Ltd., in which the Government has a considerable interest, operates one of the richest concessions known in the oil world.

The 1940 production totalled about 11,000,000 tons, as against a slightly higher figure for 1939, but this volume does not represent more than a fraction of potential output. The southern fields of Masjid-i-Sulaiman—first exploited in 1908—and of Haft Kel, 50 miles south of Masjid-i-Sulaiman, are both connected by pipe line to the huge refinery at Abadan, on the Persian Gulf. Abadan has the largest capacity of any refinery in the Near East. Other fields in southern Iran, at Lali, Agha Jari, and Gatch Saran, have been developed, with

* Events are moving so quickly in the Middle East and so little about the actual position is known with certainty that assumptions made in this article may be changed one way or the other before it appears in print.—ED. THE E.

† It has been reported in the Press that the branch pipe to Haifa has been closed and that oil is being delivered to Tripolis alone.

excellent potential output in each case. The northern field of Naft-i-Shah produces crude refined at Kermanshah, where the plant has a daily capacity of about 430 tons, and a pipe line connects Naft-i-Shah with the refinery. The fields of Naft Khaneh and Chia Surkh, in Irak, are just across the Iranian border from Naft-i-Shah.

White Oil Springs is another northern field, being about 10 miles south of Haft Kel. Drilling depths range from 1500ft. in Masjid-i-Sulaiman to 8000ft. in the new field of Gatch Saran.

Another refinery, at Bandar Shahpur, on the Persian Gulf, with a daily capacity of over 7000 tons, refines some of the crude production from the Southern Iranian oilfields.

Iran is reported to be infested with the inevitable Nazi "tourists," but here, again, should the Axis gain control of the country, the pipe lines and refineries would be easily destroyed by ground staffs, with the result that advancing troops, whilst finding copious supplies of crude oil, would not be able to obtain usable products without the necessary refineries.

Arabia.—This sector of Asia has come into the oil picture very prominently during the past few years, with the discovery of oil on Bahrein Island. The 1940 production here was over 1,000,000 tons. The oil is found at depths of 2000ft. to 2250ft. and of 4000ft. to 4600ft., with a gravity of 33·5 A.P.I. More than seventy wells have been drilled, but production is restricted owing to insufficient refinery and transport facilities. A very large refinery is operating on Bahrein and drilling on this island has assisted surveys on the Arabian mainland. Bahrein is of great strategical importance to us, and has been bombed by Italian planes, on one occasion, so far.

Saudi Arabia has been the scene of considerable activity during recent years, and Damman has a production of nearly 4000 tons per day. A pipe line runs from the field to Ras Tunara, on the Persian Gulf coast.

Further up the Persian Gulf, adjoining Irak, Kuwait, an independent Sheikhdom, is the scene of oil activity. The town of Kuwait is about 110 miles across the desert from Basra, and the producing area of Burgan is about 30 miles distant from the town of Kuwait. Potential production in Kuwait is considerable, as many wells are believed to be good for over 700 tons daily production each. The oil is of 34 gravity A.P.I., and is found at depths of 3500ft. to 4500ft. Original exploratory drilling in the Bahrah area of Kuwait was abortive, after drilling had been carried down to over 8000ft. The Kuwait area is another indication of the potentialities of Arabia as an oil-producing country.

Russia.—This country is included in the discussion, as its oilfields really come into the Middle East area. Lack of definite news from Russia makes it difficult to give a complete picture of conditions of the oil industry there, but sufficient details are known to enable comparatively accurate estimates to be made.

In 1939 production of crude oil in Russia was estimated by competent observers with knowledge of Russian conditions to be about 4,433,000 tons, and 1940 should have shown an increase on this figure.

The main producing area is in the Caucasus, especially around Azerbaidjan, Mirzany, Siazan, Baku, and other fields on or near the Caspian Sea. A little further north the well-known fields of Makhachkala, Grozny, Malgobek, Hadyzkinsk, and Maikop continue production, with exploratory drilling showing good indications.

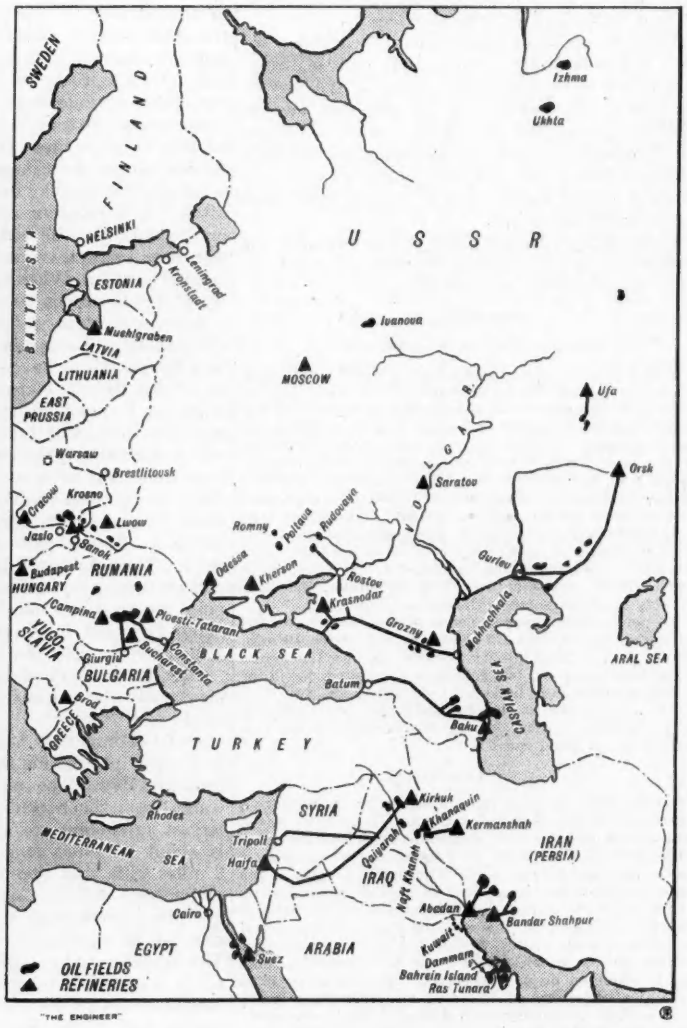
Drilling in the north-east of the Ukraine, at Romny and Poltava, has resulted in production, whilst the Ural-Volga regions have been developed with satisfactory results. In the north of the Ural-Volga area, near the Barents Sea, oil has been found at Izhma and Ukhta, whilst a new field at Ivanova, north-east of Moscow, has been opened. Much work has been done to increase production from the older oilfields in the Caucasus, by scientific development of old wells, and the finding of new production at lower levels, especially in the Azerbaidjan district. Russia has control of some of the former Polish oil areas, east of the San River, in the Lemberg area.

In spite of the fact that during 1940 more than double the exploratory work of 1939 was effected, Russian oil output is reported to be well in arrears of the volume aimed at in the current Russian Oil Plan. Lack of modern equipment is really responsible for this state of affairs, and in the latter part of 1940 the Russians ordered rotary drilling equipment to a total value of over 2½ million dollars. It was the ordering of these vast quantities of equipment, with more purchases contemplated, which caused the President of the United States to insist on export licences being obtained for the export of all drilling and general oil equipment from the States after February 3rd, 1941. Whilst it is known that Russia needs quantities of new drilling equipment, it is quite possible that re-export of such equipment to Germany was feared, and a curb on any such eventuality arising was effected by the new U.S. export licence regulation.

The majority of the Polish estimated output of over 7000 tons per day is under the control of the Russians, and this production would be a useful addition to the resources of the Nazis should they open the anticipated attack on Russia. There are many refineries in the oilfield areas of Lemberg (Lwow), and it is to be hoped that the Russians will effect total destruction of drilling, production, and refinery equipment in Poland should the Nazis advance there.

A drive through the Ukraine down to the Caucasus by the Nazis is expected, but the Russians would surely have plenty of time in which to destroy drilling and production equipment in the oilfields. There are pipe lines connecting Baku, on the Caspian Sea, with Batoum, on the Black Sea, with connecting lines from the southern Caspian oil area and the inland fields of Mirzany, Shiraki, &c. Another line runs from Makhachkala through Grozny, Maikop, to Tuapse, on the Black Sea, with a fork up to Trudovaya, in Eastern Ukraine, *viâ* Rostov-on-Don. The refineries at Baku, Grozny, Krasnodar (near Maikop), Odessa, and Kherson in the Caucasus and Ukraine are easily destroyed, and it is to be hoped that in the event of a German attack, the Russians will take care to render their oilfields and refineries completely useless, otherwise the Germans will gain supplies of much-needed refined products. Transportation of Russian crude from the Caucasus to Rumanian and other European refineries would occur only if the pipe lines were left intact, and the destruction of these lines would make it virtually impossible for the Nazis to make use of the crude oil resources of Southern Russia. There are other refineries at Moscow, Seratov (on the Volga), Ura, and Orsk, which are well away from the present German-

AERIAL VIEW OF PART OF HAIFA PIPE LINE



RUSSIAN AND MIDDLE-EASTERN OILFIELDS AND REFINERIES

Russian frontier, as are the Ural-Caspian oilfields.

CONCLUSION

From this discussion regarding the oil resources of the Middle East the reader will appreciate that there are tremendous supplies of crude oil, which may fall into the hands of the Nazis. If, however, normal precautions are taken to destroy the many pipe lines and refineries by ground forces before evacuating areas rendered vulnerable by advancing enemy troops, the Axis Powers will lay hands on plenty of oil, as crude oil, but will be unable to transport the crude to refineries, or to build pipe lines to points from which crude may be shipped to European refineries.

The difficulties of the Nazis in the obtaining of oilfield equipment and of refinery equipment are well known, since factories for the manufacture of such equipment are not numerous in Europe. Japan was used in the last part of 1940 by the Nazis as a purchaser of drilling equipment from the States. No less than 281,437 dols.' worth of drilling equipment was bought by Japan in December, 1940, and the Japanese oil industry cannot, under any circumstances, make use of such a large quantity of material, especially when one considers that the normal Japanese purchase of this equipment is only some 60,000 dols. per year. These purchases were another factor deciding Roosevelt to issue export licence regulations, and this channel of oilfield equipment supplies to the Nazis is now closed.

It is hoped that this fully detailed analysis of the oil areas of the Middle East will convince the reader that, although the Nazis may be able to conquer oil-producing countries, the use of the crude oil of such countries depends entirely upon refining facilities, and that refineries, pipe lines, and oilfield equipment—all very easily damaged—cannot be replaced by the Nazis because they have not sufficient manufacturing facilities for such materials, and the distances involved in transportation of such materials, even if available, are enormous. It would take years of untroubled effort to make use of the crude oil of the Near East, and it is hardly to be expected that we should refrain from attacking vulnerable transport points on the Nazis lines of communications, and thus permit him to develop refineries and pipe line facilities in the conquered oilfield areas.

The Electric Battery Vehicle*

By J. STEELE

INTRODUCTION

THE electrically operated vehicle takes two forms, the trolleybus and the electric battery vehicle. The trolleybus, which draws its power from the mains through overhead lines, is essentially a special apparatus used for passenger transport on well-defined routes which do not require and are not capable of frequent alteration. It has always been adopted to replace existing tramways or motor-bus services. Its high performance and low operating costs make it in all respects the equal of the motor-bus, with the limitation that it must be kept to fixed predetermined routes with overhead lines, and diversions from those routes cannot be undertaken, except those of a very short character in emergencies. As it is only used by public service vehicle operators it is of little interest outside those operators, and, so far, it does not appear to have any application except as a public service vehicle, although experiments are being carried out in the U.S.S.R. on goods transportation.

THE ELECTRIC BATTERY VEHICLE

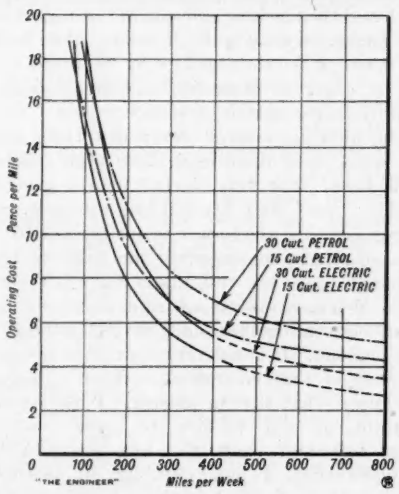
The electric battery propelled vehicle is quite a different proposition and is capable of running anywhere on any class of surface subject only to its own limitations, which will be dealt with later in the paper.

The electric battery vehicle consists of a chassis, the design of which is similar to the chassis of an internal combustion engined vehicle, the engine, clutch and gear-box of which has been replaced by an electric motor drawing its power from batteries which are mounted on the vehicle. There will be some alterations to the chassis design, due to the fact that in replacing the engine, clutch and gear-box by an electric motor the space taken up is very much less and the auxiliary equipment which is necessary to an internal combustion engine, such as the radiator, lubricating system and petrol system, is not required. The attention required by an electric motor is also very much less than that required by an internal combustion engine. This gives much greater freedom to the designer in accommodating the power unit, and the motor is usually mounted below floor level so that the driving position is brought to the extreme front of the vehicle. The chassis can therefore be shortened by the space taken up by the internal combustion engine and its auxiliary equipment. The batteries which supply the power are comparatively heavy and rather bulky, and may also enforce certain changes of design to enable them to be accommodated.

The drive from the electric motor to the back axle is quite conventional, the motor driving through a propeller shaft and bevel or worm gears to the back axle, a differential being imposed in the back axle housing exactly as on a petrol motor vehicle. Generally, the back axle gear ratio will be higher than that in the corresponding petrol-engined vehicle. It is not unusual for a petrol engine speed of 2500 r.p.m. to correspond to a road speed of about 30 m.p.h. The electric battery vehicle, which has a lower operating speed than the petrol vehicle, will have a motor speed of about 2500 r.p.m. at a road speed of between 15 and 20 m.p.h., depending upon the performance required of it.

BATTERIES

The power is supplied to the motor from storage batteries, which to-day are usually of the lead acid type, although a number of an alkaline type are in use. The lead acid type is considerably cheaper in first cost than the alkaline type, but is also much heavier. The alkaline type has a far longer life, between two and two and a-half times the life of the lead battery; but, while being lighter, takes up rather more space for the same watt-hour capacity, and also has a somewhat lower efficiency than the lead acid type. The battery is mounted on the chassis, either in a number of small units which are placed between the chassis members or hung closely adjacent to them, or alternatively in two battery containers suspended within the wheel base in such a manner that the battery containers can be rolled or lifted out without disturbing the pay load. This latter method is probably the better of the two, since it enables inspection of the battery to be undertaken at any time and also enables the battery to be taken out and replaced with a fully charged one in a short space of time. It does, however, involve a rather heavier design of underframe. The battery has no moving parts and works on a reversible electro-chemical reaction.



OPERATING COSTS OF PETROL AND ELECTRIC VEHICLES

Batteries, of whatever type, are somewhat heavy and bulky, and the amount of power which can be obtained from the material is limited. It is difficult to mount sufficient battery capacity to give more than about 35 to 40 miles per charge without reducing the space available for goods or increasing the tare weight of the vehicle and decreasing the weight of goods which can be carried.

CHARGING

The electric battery vehicle is generally charged at its garage, each vehicle having its own automatic charger. The modern charger is of the dry metal oxide rectifier or thermionic valve type, with mercury arc rectifier types for the larger vehicles or where group charging can be arranged. Whichever type is adopted, the charging is completely automatic. The driver at the completion of his duty inserts the charging plug into the socket on the vehicle and switches on the power. The characteristics of the charger are such as to cut down the current as the battery approaches the fully charged condition, and when the battery is fully charged the power is cut off by means of an automatic contactor or circuit breaker. The contactor or circuit breaker is controlled either by the ampere-hour meter on the vehicle, which registers the power taken out of and put into the battery, or by means of a relay on the charging panel, which by means of a voltage relay determines the condition of the battery. In neither case is any attention required except that once a fortnight a low rate additional charge should be given, and this will require the cutting out of the contactor or circuit breaker and the cutting off of the charge when, by battery voltage and acid specific gravity reading, it has been ascertained that all cells are fully charged. This usually coincides with all vehicle routine inspection.

OPERATION

The operation of any new form of transport may involve a reorganisation of the methods adopted to enable the maximum use to be made of the new medium. This was so when petrol vans took the place of horses and when long-distance road haulage superseded railborne transport. The electric battery vehicle is no exception to this rule and since it has a limited range of from 35 to 40 miles which cannot be easily extended, and a limited speed, there are only certain duties for which it is suited. These duties are schedule delivery work where the same route is gone over frequently with many stops for the delivery and picking up of merchandise. There are many such duties—distributing goods to depots and shops, delivery from shop to customer, transferring goods from warehouse or railhead to stores and shops. Under such circumstances the electric battery vehicle shows up to great advantage. High speed is of no value, since the distance between stops will be low and much of the total time will be made up of delivery or loading time. High acceleration, a feature of the electric vehicle, is of advantage, enabling the vehicle to move out into the traffic stream promptly. The limited mileage will not cause any difficulty, since vehicles on such duties cannot do a large mileage, owing to the large proportion of time spent at rest. During the stopping time no power will be needed and no wear and tear will be taking place. The vehicle will start off instantly whatever the weather conditions, and there is no risk of freezing up of any part, however long the vehicle may have been standing.

Many operators of large fleets of vehicles would find it possible to use quite a number of electric vehicles, but they would not be interchangeable with the remainder of the fleet, since their characteristics are different, but if used for suitable duties it will be found that the electric will carry out the work quicker and cheaper than the petrol.

COST

This is a point about which operators will require the fullest possible information, and estimates drawn up by manufacturers or other propagandists will be looked upon with some reserve. I will therefore refrain from quoting operating estimates of my own and will refer to those drawn up by "S. T. R." and published by the *Commercial Motor*, as being typical of such costs. I quote the figures for two typical vehicles of a type commonly in use, namely, 15-cwt. and 30-cwt. carrying capacity, and have plotted these costs in the form of a curve as well as giving a tabular statement, so that it can be seen how the costs are made up.

Cost Table

	15 cwt.		30 cwt.	
	Petrol.	Electric.	Petrol.	Electric.
Standing charges (per week):				
Licences	8·0	4·0	10·0	6·0
Wages	68·0	68·0	73·6	73·6
Rent and rates	5·0	4·6	6·0	6·0
Insurance	6·10	5·2	7·6	7·3
Interest	3·3	5·0	3·6	7·3
Maintenance	—	6·4	—	12·9
Depreciation	—	26·6	—	35·6
Total standing charge per week	91·1	119·6	100·6	148·3
Running costs (300 miles per week):				
Fuel	1·3	0·42	1·9	0·60
Lubricating	0·08	—	0·09	—
Tyres	0·32	0·35	0·42	0·50
Maintenance (routine)	0·47	—	0·53	—
Maintenance (repairs and overhaul)	0·36	—	0·63	—
Depreciation	1·15	—	1·25	—
	3·68	0·77	4·82	1·10

If the table be examined it will be seen that most of the electric costs are standing charges—this arises because both maintenance and depreciation are more nearly due to time rather than distance; the distance possibly being limited. In addition, some operators will consider that tyres may also be a fixed charge, especially where the weekly mileage is very limited. The cost of power is insignificant, although the price is taken as 1d. per unit, and it can generally be obtained at lower rates.

In drawing up the curve I have extrapolated the electric curves to 800 miles, a mileage which is impossible, to show the trend as compared with the petrol vehicle.

It will be seen that the costs are considerably below those of the petrol, and this is due to the long life of the chassis combined with the low maintenance costs of the vehicle. It should be stated that the depreciation includes battery renewals at intervals of three years, as well as a suitable figure for the body and chassis. Many other figures could be given showing a much lower total cost, but this equally applies to the petrol vehicle, and it is felt best to leave these figures as they are.

* The Institute of Fuel, February 27th, 1941.—Abstract.

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BLACK COATS AND OVERALLS

AMONGST the industrial problems that should have been settled before the war and that will have to be settled after it, is the growing divergence between skill and knowledge. Ideally, they should move together along the same path, knowledge leading to the better use of skill and improved skill augmenting the value of knowledge. That ideal lies behind all the schemes for improving the education of skilled artisans. The presumption is that with increase of understanding and intelligence the skilled workman will be better than when he relied, as in the past, on skill alone. There is no lack of evidence that that presumption is justified by the results. Managers are satisfied that as intelligence is developed by education, better use is made of skill; in short, that the well-taught apprentice or journeyman makes a better workman than his untaught neighbour. All the schemes of workshop classes and the encouragement of attendance at evening classes are founded on this belief, and over and over again the soundness of the plan has been proved.

So far, so good. Up to this point there is complete accord. The educationist is satisfied and the employer is satisfied. The intellectual standard of the country has moved upwards, and its skill has increased. Nothing could be more satisfactory were it not that a human weakness intervenes, and, like the worm in the bud, mars the happiness of the union between knowledge and handicraft. Since Good King Albert came amongst us, a kind of intellectual snobbery has grown up, even in the workshop. There was a time when the first-rate mechanic held his head high. He knew his worth and his employers knew it. He scorned "book learning," and rejoiced in the magic that his hands could perform. He was the cock of the walk, and the black-coated lads in the office were but small beer. Then a change began to take place. Clever people came along and began to depreciate the qualities that their fathers had exalted. They took away the calipers and gave the workman go and not-go gauges; they made foolproof machines and employed a tool setter to set up the work; they took the grindstones from their corner under the gallery stairs and ground all tools scientifically in a reserved compartment; they scorned hazel wands for the measurement of temperatures and introduced the microscope to replace the skilled steelworker's analysis by fracture. In a hundred ways the skilled workman was made to feel that he was not what he had been, and that he was being deposed from his once high position. So it came about that instead of being proud of the craft of his hands, the young workman began to feel ashamed of it; his ambition was to exchange his blue overalls for a black coat. To do that he began to educate himself. He took evening classes, went a-hunting for scholarships, and qualified for a National Certificate or a university degree. For all of which he merits the highest praise. But the unfortunate result is that the very men whom it was hoped would make the best workmen left the bench and the machine and sought positions where they might use their brains instead of their hands, and move up the social ladder by wearing a black coat in place of dungaree, and by drawing a monthly salary instead of weekly wages.

Education has always been a disturbing thing, and never more disturbing than when taken in small doses. The very learned man is generally humble; the partly learned one arrogant. The latter more than the former is apt to overrate the value of mind and underrate the value of body. In recent times the two things have got out of scale. Men have even imagined devices for getting rid of body altogether, and leaving nothing but pure intellect. It is not very clear what use could be made of that emanation without a body to react upon—but that in passing. What we have to think of now is how to bring down the black coat and exalt the blue overall; how to make skill of hand as high in the social scale of the industrial world as book learning. One way of doing that would be to pay the craftsman so highly that he could rustle it with the best of the black coats. But, save in a few industries, it would be hard to make that an economic proposition. The alternative is to persist constantly in the effort to reduce the number of skilled people required. We thought we had gone a good way with that plan till the war showed us how far we were still from it. Could we make all workshop operations, even tool-making, automatic, then skill would be no longer required, and we might devote our attention to the education and training of an army of black-coated directors of operations. But we are a thousand miles from that consummation, and in the meantime the best men are seeking to get into black coats and contemning their overalls.

Lay Inventors

No doubt the tide of public invention, like that of the ocean, has its periods of ebb as well as of flow, but the period selected for recent reference in Parliament must surely have been at a spring tide, for the speaker disclosed that in one single month last year no less than 40,000 inventions of one kind or another were sent in to the Air authorities alone! This, we think, must have been a decided crest, for an invention rate running at nearly half a million a year for one Defence Service alone is almost incredible, even in these days, and one must bear in mind that towards the other Defence Services also there is sure to have been a strong tide running. Given though they are to studying the numerous inventions of their fellow-technicians, engineers cannot but be astonished at the enormous numbers of the general public who are moved by the stress of the times to put forward inventive proposals of their own.

When the magnetic mine was proving a sudden and troublesome menace, the stream of public inventions rose to a spate. That threat was handsomely and quickly countered, but how far, if at all, the discovery of the antidote was assisted by suggestions received from the public we do not know. Yet it is certain that the general public is becoming increasingly interested in all technical matters. Never before has the lay mind proved so fruitful in new ideas as it now shows itself to be. In the Four Years War no such phenomenon was seen. Then the flow of air inventions, to take that as an example, was a mere trickle, despite the novelty of the subject and the immense area of the new field available for exploration. The Air Inventions Committee of that day, under the fatherly guidance of its Chairman—a member of the great Darwin family—had a comparatively light task. When it was completed, by the ending of the war, the Chairman made the arresting statement that his Committee could easily have attained the high engineering performance of 98 per cent. efficiency, merely, he explained, by drastically rejecting every single proposal received, seeing that only one invention in every fifty was any good! We do not know what the proportion may be in these more prolific days, when the public is entering this competition of ideas on so large a scale, but we doubt very much whether the proportion of useful inventions is likely to be nearly so high as this. Two per cent. of half a million would be 10,000, and the "winners" cannot possibly be so numerous as that. The great proportion must prove on examination to be mere repetitions of each other or of inventions made long before. The policy of the Government in having every one of these many inventions carefully examined is, we believe, the correct one, despite the small fraction likely to prove both original and useful and of the enormous amount of work which must be involved in this examination. Concealed in the great mass of material there may be found some useful ideas, and the labour of the search is a labour that needs to be faced. Even though a particular suggestion is not original in itself it may be useful as a pointer towards some new line of investigation or to one hitherto neglected. More than this, there have been cases in the present war in which distinctly useful ideas have been brought to light by this sifting process, and in war no aid towards victory can be ignored. That is the technical aspect of the matter. There is also the human one that every individual in the British Commonwealth should feel himself free to render any service he can to the common cause, and not only be free to do so but be welcomed when he makes the effort. This is clearly the right policy for the Government to adopt, even at the price of having to maintain a considerable staff of technicians to examine the many schemes submitted, and assiduously to sift the wheat from the chaff. In the case of such popular subjects of invention as that of the counter to the night bomber, there must no doubt be duplication by the thousand, as well as of schemes too obviously grandiose, as well as those seemingly modest suggestions which, turned into figures (which for some reason most inventors seem to be chary of doing), would represent an expenditure of labour and material quite incompatible with essential war requirements. Not only must these scrutinies be made, but a reason, however brief, must in all cases, where it is at all possible, be given for the decision reached.

In most cases the inventor will not be sufficiently informed of current technical attainments in the area to which his suggestion relates, and this ignorance is often his undoing. We do not know how far lay inventors may be numbered among our readers, but to any such we would give this word of advice: Take whatever steps may legitimately be available to learn something of the technical position of the art to which you propose to contribute. This will save duplication of effort, and make it much more likely that the invention will prove of real service to the common cause.

James Nasmyth as a Tool Maker

By H. W. DICKINSON, Eng.D. (Lehigh)

IN July, 1940, the Bridgewater Foundry, after a career of well over a century as an engineering establishment, came to an end, and became a Government ordnance factory. In the consequential arrangements and clean out, Nasmyth's famous "Sketch Book" and a portfolio of early drawings, about a hundred in number, were presented to the Institution of Mechanical Engineers, Westminster, by Sir Holberry Mensforth, K.C.B., C.B.E., M.Sc., M.I. Mech. E., and can be consulted in the library there. Most of the drawings are of Nasmyth's steam hammers, on which his fame chiefly rests, but apart from these, there are a number relating to his machine tools, and it is to a review of his achievements in this field of effort that this article is confined. The temptation to go outside this purview has been resisted, because the history of the firm, Nasmyth's partnerships, his steam hammer, his floating mortar, and the locomotive building begun in 1839, for which the firm remained justly celebrated to the end, have been already described and illustrated in our columns. In that article[1] his machine tools were barely touched upon, so that this article will serve as a complement to it.

Before coming to detail, it is well to visualise the background as regards tools at the time when Nasmyth began his engineering career in 1826. Few mechanical workshops existed, except perhaps the celebrated Soho Foundry, that were furnished with more machine tools than a vertical or horizontal cylinder boring mill and a few lathes, not always slide lathes and rarely screw-cutting. At that time machine parts in cast metal were moulded as close to size as possible or with fitting strips; wrought iron parts were forged by the smith practically to finished sizes, and fitting was mainly done by chipping and filing.

As regards his own career, after three years' preparation at home and a short period as private assistant to Henry Maudslay at Lambeth, cut short by the latter's untimely death in 1831, Nasmyth returned to Edinburgh, his home city, and began preparing an outfit of tools with the intention of starting in business for himself. When ready, he looked around for a suitable locality, and in the course of his search in 1834 visited South-West Lancashire. He decided that Manchester should be that locality. Writing of this visit he observed: "I . . . found that the demand for machine-making tools was considerable, and that their production would soon become an important department of business. It might be carried on with little expenditure of capital, as the risks were small and the returns were quick. I resolved to cultivate that moderate and safe class of mechanical business."[2]

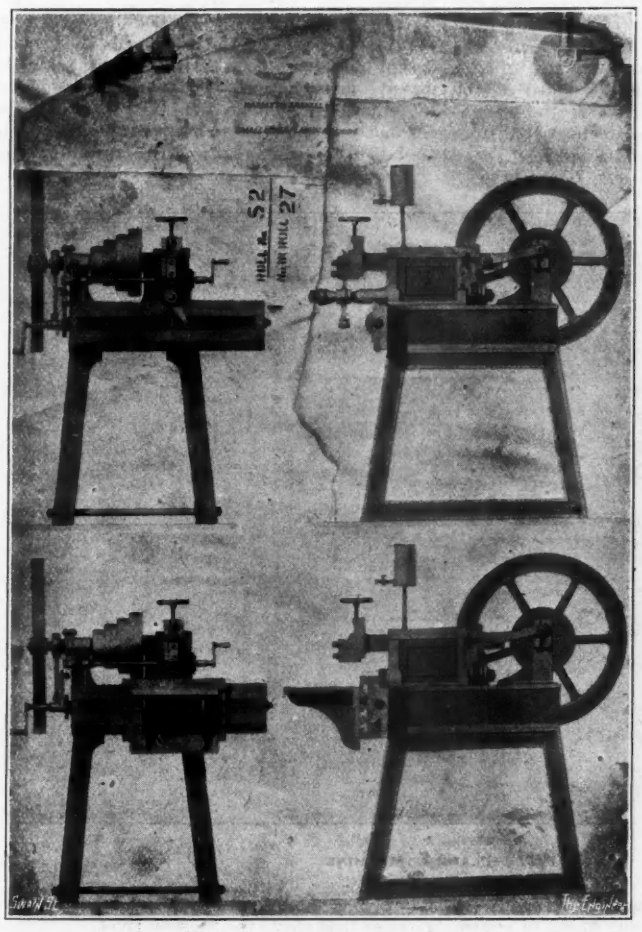


FIG. 1—"LEVER PLANING MACHINE"—1836

Manchester was already known as a tool-making centre, and he started in business by taking premises in Dale Street, Piccadilly—the first floor of an old mill, with power included, at the rent of £50 per annum. He was satisfied with his decision, for he remarks in another place[3]: "Shortly after the opening of the Liverpool and Manchester Railway, there was a largely increased demand for machine-making tools." This was true, and other engineers, like Richard Roberts and Joseph Whitworth, to name two in Manchester alone, took up tool making. Continuing, Nasmyth says: "It so happened that the demand for machine tools consequent upon the increasing difficulties with the workmen, took place at the time I began business in Manchester, and I had my fair share of the increased demand. Most of my own machine tools [*i.e.*, those in his own shop] were self-acting—planing machines, slide lathes, drilling, boring, slotting machines, and so on. When set up in my workshop they distinguished themselves by their respective merits and efficiency. They were, in fact, their own best advertisement."

The Dale Street premises were quite unsuitable for heavy machinery, and, moreover, vertical space was limited by the floor above, so much so that, having taken an order for a beam engine, Nasmyth had to have recourse to building it on its side! When being taken to pieces for shipment, his men dropped the beam, and it crashed through the floor. This was the final blow to the patience of the ground-floor tenant—a glass dealer, of all trades!—who had been complaining bitterly of the disturbance. Nasmyth had to clear out.

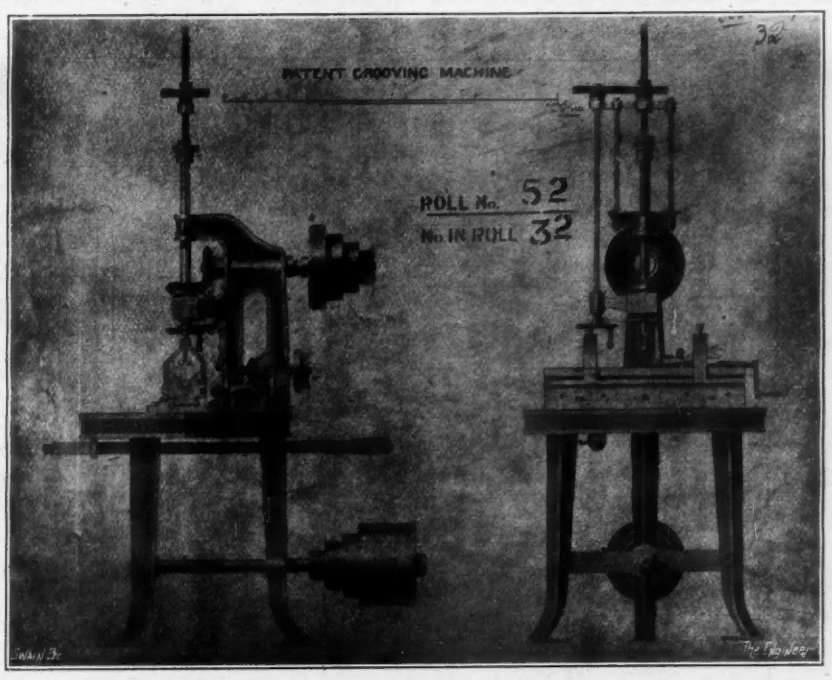


FIG. 2—"PATENT GROOVING MACHINE"—1847

In his search for a suitable site for works, he recalled having seen a plot of land at Patricroft, bounded by the high road, the Bridgewater Canal, and the recently constructed Manchester and Liverpool railway line. He secured a long lease at a low rental, and in August, 1836, removed the contents of his workshop thither, installing them in temporary buildings. Thus arose the celebrated Bridgewater Foundry, so named by Nasmyth in honour of the Great Duke. His outfit of tools had been largely augmented during his stay in Dale Street. He still possessed the lathe that had belonged to his father, to which he had added a slide rest, and a planing machine he had made at Edinburgh. The history and fate of the latter will be touched upon in the Appendix.

The stage could not have been set more auspiciously for success. Nasmyth was in his twenty-eighth year, and from then till he was forty-eight—the years when a man is most prolific in invention—he toiled there with scarce a break, his reputation growing and his fortune increasing year by year. The period 1835–40 was a particularly strenuous one, for during it he designed and made quite a score of new tools. If we are to judge of what he accomplished by the conspectus shown in Buchanan,[4] where almost as large a number (twenty-one) of his tools, as compared with that (thirty-three) of all other makers put together, are figured, obviously because of the opinion of the editor—and this opinion would be backed by any unprejudiced engineer then or now—they were then the most advanced in design and fitness for their intended purpose of any to be had. In stating this opinion, allowance must be made for the fact that Nasmyth was more willing than other engineers to disclose his designs, for his considered policy was, as above stated, to rely on the excellence of his products as their best advertisement. This is borne out by the fact that, although a prolific inventor and designer, only one of the eighteen patents, excluding steam hammers, that were granted to him was specifically for a machine tool. A factor that contributed greatly to the excellence of his designs was his inherited artistic perception of correct proportion.

[1] "Short Histories of Famous Firms," No. 111, Nasmyth, Wilson and Co., Ltd., Vol. 129, March 19th, 1920, page 287.

[2] "Autobiography," 1883, page 182.

[3] *Loc. cit.*, page 199.

[4] Robertson Buchanan, "Mill Work and Other Machinery," third edition, by George Rennie, 1841, Appendix B, page 411 *et seq.*

The plates in Buchanan are prefixed by "Remarks on the Introduction of the Slide Principle in Tools and Machines employed in the Production of Machinery," by Nasmyth, in which he stresses the copying or slide principle which is basic in all tools. These remarks are as valuable to-day as when they were penned. He also treats of the design and the setting of cutting tools, a subject that, as he says, "has not either received that attention which the importance of the subject calls for, nor has any attempt been made to reduce the subject to such plain and general principles of which it is not only capable, but when so treated, then only adapted to be of service to those in whose hands the management of such tools is for the most part entrusted." There is quite an anticipation of the tool-room in this last remark.

He was the first, so far as we are aware, to analyse the angles that a cutting tool must embody, and to design a gauge to enable a tool to be ground to these correct angles.

It should be mentioned that in 1838, owing to rapidly extending business, Nasmyth took the wise step of engaging technical assistance—that of a fellow-countryman, Robert Wilson (1803–82), from Edinburgh, who was made works manager. He was a clever engineer, and undoubtedly gave Nasmyth much respite from routine and much help, especially in the development of the steam hammer. He left for a time to become manager at Low Moor ironworks, but on Nasmyth's retirement in 1856, he was invited back as managing partner, and was the mainstay of the firm on the engineering side till his death in 1882.

Coming now to detail, we can only pick out for mention tools which were important in themselves or because they are illustrated in the portfolio. A complete review of Nasmyth's work would take up more space than can be afforded, and must await better times. Leaving on one side gadgets, the first important tool invented by Nasmyth—this was in 1836—was the "lever planing machine" (see Fig. 1), nicknamed "Nasmyth's steam arm," or what has since been known as the shaping machine, the object of which was to obtain the advantages of the planing machine for the smaller or detailed parts of tools and engines. The work in this case is fixed and the tool is in a box on the end of an adjustable slide reciprocated by crank and adjustable stroke connecting-rod. The work table is bolted to the framing in front of the tool, and had a cross feed, either hand operated or automatic, while the tool was supplied with a vertical hand feed. The machine had a fitting by which segmental work could be dealt with, such as a link. Another fitting sometimes supplied was an attachment for milling hexagon or square washered nuts, a device which he had brought out as far back as 1829 while he was with Maudslay. It is to be borne in mind by our younger readers that this tool, as in the case of others to be described, was driven by belting, *i.e.*, fast and loose pulleys, step pulleys for speed changes usually, and a flywheel.

In 1838 Nasmyth patented (No. 7815, September 20th) the machine for cutting key-seats in wheels and pulleys. Maudslay's mortising machine for block making was doubtless the prototype, and this had been transformed for cutting metal by Roberts to supersede hand chipping and filing. The machine of the latter consisted of a vertical slide tool box receiving motion from an adjustable crank. The wheel or pulley to be key-seated was fixed on a horizontal slide table with a hand feed. The drawback to his tool was that its capacity was limited to wheels whose radius was not greater than the distance between the standard of the machine and the slotting tool. Nasmyth got over this by placing the tool in a post reciprocated from a crank below through the boss of the wheel. There was an entire absence of springing and a heavier cut than before could be taken, while, of course, there was no limit to the diameter of the wheel in question. A further advantage was that the tool occupied less space in the shop than, and its cost was only about one-third of that of, the older type.

The next tool selected for notice is the slot drilling and keyway cutting machine, which Nasmyth called his "Patent Grooving Machine" (see Fig. 2). The word "patent" is an error, however. This is a particular adaptation of his drilling machine[5] for cutting cotter holes in piston-rods, &c., and keyways in shafts, previously performed by laboriously drilling a row of holes and chipping away the intermediate metal. The date of it is given as 1847. The particular feature was the shape of the flat drill. The centre part was cut away, so that it could cut on the edges, and, thus, by a traversing slide with two self-acting feeds, it could cut a slot. The rate of output was at least ten times that of hand work, and its merits became known and appreciated to such an extent that the Foundry was never short of orders for it.

We notice next the "Small Paring Machine" (see Fig. 3), or vertical slotting machine. The date on this drawing is 1848. It may be considered to be a development of Roberts's keyway slotting machine. The cutting stroke of the tool is downward, and can be varied as before. The improvement is that the work is held on a slide table with hand feeds in two directions, and the top table has a tangent feed, so that work of curved outline could be accomplished.

Nasmyth made considerable progress in the development of the planing machine. He had made one at Edinburgh and he used the experience thus gained in the one we have selected for illustration (see Fig. 4), which is one of the smaller sizes, viz., 3ft. stroke, in which the reversal was effected by a mangle-wheel motion. The length of the stroke of the table could be varied by removing a pin in the mangle wheel at the appropriate point in its circumference. The table reciprocated by a chain on two vee guides, with the apex of the vee upwards; no doubt, the intention was to prevent choking with chips, but it had the disadvantage that the lubricant ran off. The cross slide for the tool had an automatic feed and other adjustments were in line with the current practice of Roberts and Whitworth. A machine built in 1857 for Nasmyth's private workshop at Hammerfield, in Kent, is preserved in the Science Museum, South Kensington.

Boiler-making was a craft that became largely localised around Manchester, the birthplace of the Lancashire boiler, and the demand for rivets for this purpose and for constructional work led to the design of the "rivet-making machine" (see Fig. 5). A demand had arisen also for bolts for railway fish-plates. The date on the drawing is 1848, but the design must have been earlier. The machine is of massive construction. The power is transmitted by reducing gearing to a crank oscillating a beam on each side and close to the centre. These beams actuate two plungers working suitably shaped dies below. One end of the beam by a rod works a plunger that ejects the finished rivet.

The last tool we shall notice is the "patent double lathe" (see Fig. 6). Nasmyth, however, had no patent for it. He gave the date as 1850, and called it a "Double or Ambidexter Self-acting Turning Lathe, with Dead Cutters, specially

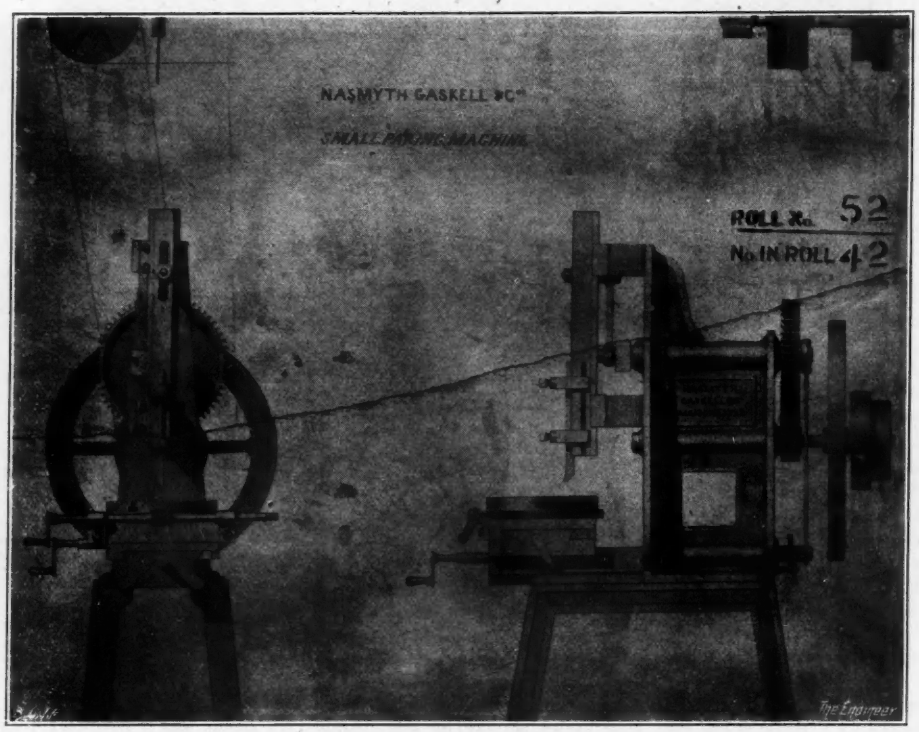


FIG. 3—"SMALL PARING MACHINE"—1848

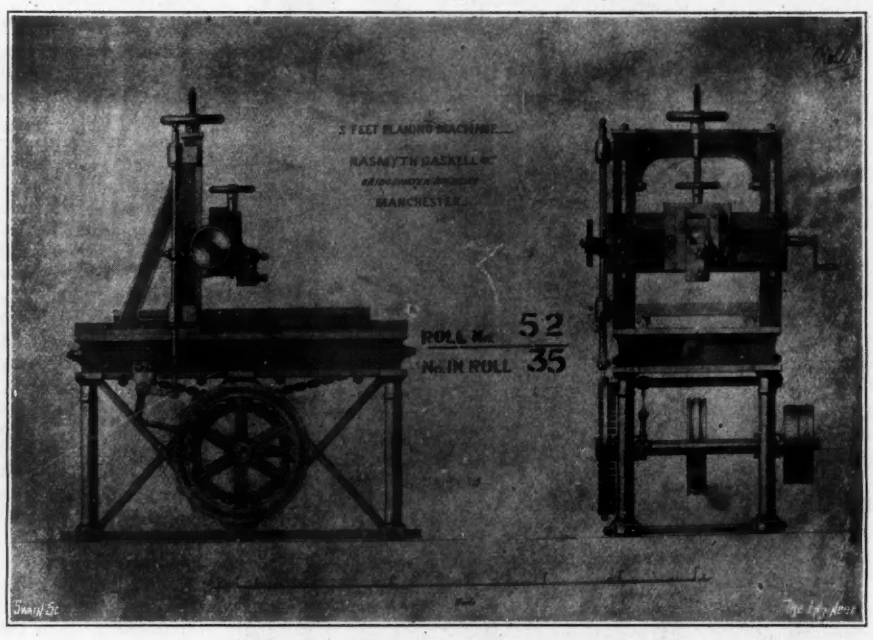


FIG. 4—PLANING MACHINE

[5] "Autobiography," page 433.

adapted for Turning Bolts and such-like Detail Parts of Machinery." It consists really of two 5in. slide lathes in line on one bed, each with slide rest, self-acting gear, and independent drive. All that there is in it is a labour-saving device for repetition work, whereby one operator could attend to two machines, and is a stage on the way to the automatic lathe.

We could go on at length giving details of other

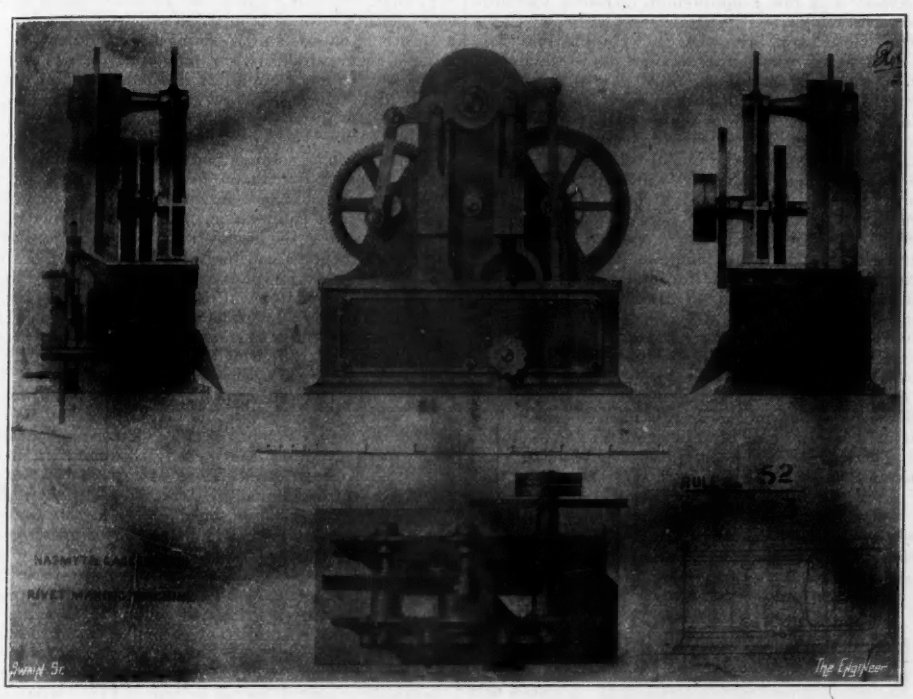


FIG. 5—RIVET MAKING MACHINE—CIRCA 1848

tools illustrated in the portfolio, but we shall merely remark that he touched nothing he did not improve and was ready to design a tool for almost any job. He did not confine himself to metal either, for he made wood-planing machines and a machine for cutting the teeth of wooden patterns or models.

We are indebted to the Council of the Institution for permission to reproduce the figures in the text,

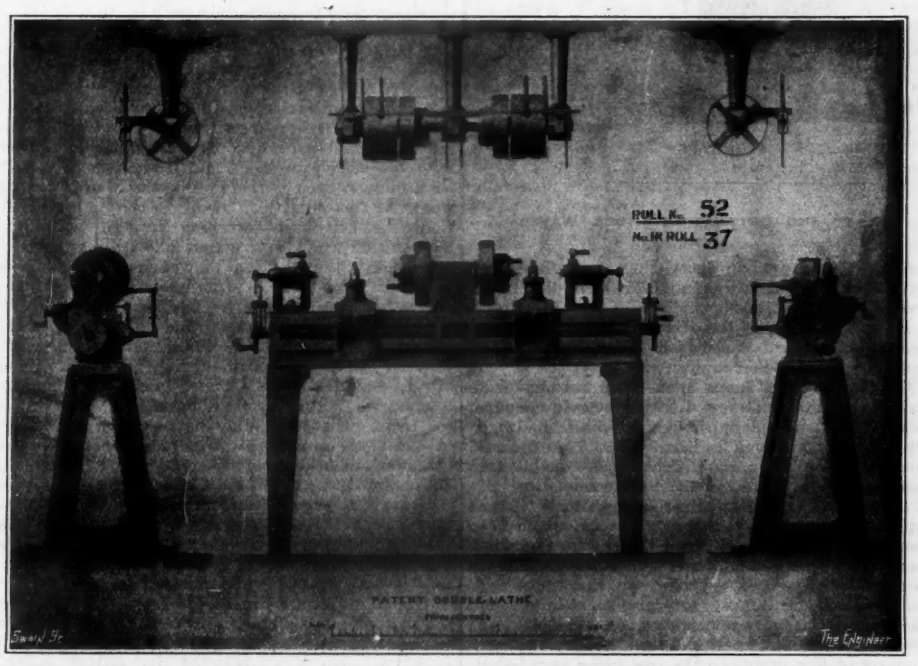


FIG. 6—DOUBLE LATHE—1850

and for assistance in the preparation of this article.

APPENDIX

TRANSCRIPT OF LETTER OF JAMES NASMYTH TO ROBERT WILSON

Penshurst, Kent,
Feb. 9. 1864

DEAR WILSON,

Many many thanks for your valued letter which together with its accompanyments interested me exceedingly—It is very kind of you to think of sending me the old planing machine with which I have so many associations! but my space for accomodating any such object is so very limited and my occasion for using such a machine quite out of the question that I must just accept your kind offer for the deed and return you my best thanks and acknowledgements for the proposal all the same—There is however one part of it I would like to have by me that is the ratchet wheel with its ratchet arm and pall. The wheel I cast my-self and a considerable part of the metal of it was derived from a pair of old candle sticks that I begged of my Father who had them on a shelf of his work-shop. He gave me them in consideration of the use they were to be put to telling me that they were the first pair he and my mother set up house with and that they had held the candle to many a crack with Burns! so you see they are in a good sense reliques! in so far as they were in the said wheel which has done *its* duty in its way. If I might venture to suggest if the machine in question is cumboring the premises it would be well to dispose of it for what it can fetch and hand over the proceeds to the Patricroft Institute. It would be far more pleasing to me and worthy of the machine to pass into the hands of per-adventure some hard working beginners who might in their turn cause it to do good service for it is far more glorious for a good old machine to work away to its last very last powers than to lay idle as a cumborous curiosity? or piece of lumber as the case may be—I am delighted with the 3 cylinders press it is a most happy thought the center arm dragging up the side ones and filling them with water to be all ready to give forth a grand final squeze when the time for it comes in every respect it appears to me to be "the Right Thing" and doubt not it will long long continue to be considered so—

The Photographs are admirably done and worthy of the subjects—are they done by my Friend J. Mudd or who did them? It is a most valuable art that of Photography for all such uses. The wonderful truth and precision of the ideas they convey in so condensed a form is glorious and must be a vast aid in correspondence in such subjects—

I am much pleased to see you have adopted the "Box pattern" design of frame work for the tools, &c. It is the right system of Design in every respect and I also note the nice rounded corners and edges and hollow angles in all parts—to the great security of shinns and knuckles as well as avoiding sniped edges. I should be very much obliged if you would now and then treat me with a sight of a Photo of any new tool or machine you bring out as it is just like seeing the thing itself.

I am happy to know you are so throng and that with presses and hammers. I must be down to Woolwich to see the 20 ton hammer! and pass my hand over the grand casting! have you put up new cupulas to enable you to cast such big jobs? two 15 ton screw ladles would be wanted to run them I fancy?—The Travelg crane between the shops and over the Boat Loading part of the canal will be a mighty advantage—one is also much wanted to pick up heavy casting Boxes &c., at end of the Foundry. It is the right sort of crane for almost every purpose. My notion of the Gun of the Future is a vast Ingot of Bessemer or other mild cast steel knobbled down at a low red heat by fine Kneading Blows from a 20, 50 or D ton St. Hammer with low fall as much done in J.N. his V anvil as possible so as the Blows be not allowed to squash out the metal and make it loose or hollow in the center. I have no faith in welded or built up guns for the larger sizes. We must have solid Ingots like those of Kraup in the Gt Exhibition 1862 and knobble them down as aforesaid in V anvil. Parrellel surfaces always tend to squash out and make loose centers[6] this is an old story no doubt but it has not been told so often yet till it be in general practice.

I am very throng with lots of little hobbey jobs and never find the day too long for what I want to do with it.

I am in hands with a 12in. Glass *unsilvered* speculum where with to follow up that curious discovery I have made as to the structure of the suns surface which I found to be formed of an infinity of willow leaf shaped objects crossing each other in every random direction. They are about 1000 miles long by 90 wide each! it is them that yeald us the light, how they do so God only knows. This discovery has made a great stir amongst astronomers many of whom are very vexed *they* did not make it before me, so I have written my name on the sun and will go down remembered with him vanity of vanity! but joking apart this is rather a grand discovery as all such must naturally be that adds to our knowledge of the glorious centers of our system and by annalogy that of all the Fixed stars. So Nasmyths Willow leavs are held in high regard. I hope by the use of the unsilvered glass speculum and no Tube and a clear flange Diagonal to get quit of the disturbing currents that make it so rare and difficult to catch the tranquil moments and so perhaps get to know a little more about these remarkable objects. Excuse this long Havers from yours truly

JAMES NASMYTH
his marke

N.B.—The "marke" is that of his thumb print.

Air Force Targets in Germany

FOR many months we have printed at frequent intervals descriptions of places in Germany which have been bombed by Great Britain and her Allies. The targets have been selected week by week with some attention to topical interest, or what editors call "news value," but one has only to look at a now familiar poster to see how frequently the same district receives the attention of the Bomber Command. Topical interest may therefore recur long after our description appeared. To satisfy it, we give below a complete list of the series up to date. The articles have excited so much interest that it is our intention to continue them and the following list will be published from time to time with the latest additions :—

	1940.
No. I.—Kiel and the Kiel Canal and Hamm Marshalling Yard	July 12th
No. II.—The Dortmund-Ems Canal	July 26th
No. III.—Emden and Wilhelmshaven ...	August 9th
No. IV.—Junkers Aircraft Works at Dessau	August 30th
No. V.—Two Berlin Power Stations (Klingenberg and West)	September 27th
No. VI.—Map showing bombing attacks on the Ruhr District	October 11th
No. VII.—The Lauta Aluminium Works ...	October 18th
No. VIII.—Bitterfeld Aluminium Works ...	October 25th
No. IX.—Germany's Aluminium Industry and Rheinfelden Aluminium Works ...	November 1st
No. X.—The Leuna Works of the I.G. Farbenindustrie...	November 8th
No. XI.—Pölitz Hydrogenation Works near Stettin...	November 15th
No. XII.—Sterkrade-Holten Oil Works ...	November 22nd
No. XIII.—Duisburg-Ruhrort Harbour ...	November 29th
No. XIV.—The Port of Hamburg and its Shipbuilding Industry	December 6th
No. XV.—Cologne and its Environs	December 20th
	1941.
No. XVI.—The City and Port of Mannheim	February 14th
No. XVII.—Ludwigshaven-am-Rhein ...	February 21st
No. XVIII.—Bremerhaven and Bremen ...	March 14th
No. XIX.—Bremerhaven and the North German Seaports	April 4th
No. XX.—Düsseldorf and its Engineering Industry	May 9th
See also	
The Brenner Railway	February 7th
The Oil Situation in Rumania	April 18th
The Oil Situation in the Middle East ...	May 23rd

CAMP CONSTRUCTION.—For the accommodation of troops under the U.S.A. defence scheme an Army camp at Indiantown Gap, Pa., has been built in less than six months. The work entailed the organisation of a staff of 13,000 men and the construction of 1054 buildings, 25 miles of new roads, a sewage treatment plant, 22 miles of sewers, 25 miles of water mains, a 500,000-gallon steel water tank, with 34 miles of power distribution lines.

[6] A small hand sketch (not reproduced) occurs here.

Explosives*

By G. I. FINCH, M.B.E., D.Tech. Chem., D.Sc., F.R.S., M.R.I.†

AN explosive is a store of chemical energy which can be rapidly converted into heat and thence into mechanical energy. A mixture of hydrogen and oxygen in their combining proportions is explosive. When suitably initiated a speedy reaction occurs, whereby the chemical energy of the mixture is largely transformed into the heat energy of hot steam, which, by expanding, does work upon its surroundings. In the course of the process four outstanding facts are revealed.

In the first place, the explosive mixture is inherently stable in the sense that, in order to unlock its own store of chemical energy, a certain, generally small, amount of energy must be supplied from outside. It is as if a ball were resting in a cup-shaped recess at the top of an incline; that is in order to begin the conversion of its potential energy into the kinetic energy of motion a certain amount of initial energy is required. Secondly, it will be seen that the volume of the freshly formed explosion products is much greater than the initial volume of the explosive mixture; and, further, a flash of flame testifies to their high temperature. Finally, the conversion of chemical energy occurs with such rapidity that the expanding hot steam, in pushing away the surrounding air, compresses it so abruptly that it gives rise to a steep-fronted sound wave. The expanding gaseous explosion products and the rush of displaced air which they drive before them is what is known as blast; but the steep-fronted sound wave, which travels ahead of and faster than the blast (see illustration) and affects our hearing like the sharp crack of a whip, is the shock wave. As this shock wave travels through the air its intensity decreases; but what is more important, the shock wave front also becomes less steep, so that the sharp crack which acutely and even painfully affects our hearing near the source of the explosion soon degenerates into a softer and more drawn-out sound which can be tolerated without discomfort.

I have begun by illustrating some outstanding properties of an explosive by means of a mixture of gases; it is usual, however, to confine the term to solids and liquids. An explosive is, then, a solid or liquid substance which does work at a high rate upon its surroundings through the rapid conversion of its chemical energy into the heat energy of gaseous explosion products. The products must be gaseous, either wholly or in part, because the heat energy of solid or liquid explosion products is not directly available for doing work by expansion.

It is a popular fallacy that an explosive is an unusually rich store of energy. The fact is that a 2-gallon tin of petrol is capable, given sufficient air, of doing as much work as 6½ gallons of nitro-glycerine, one of the most powerful of explosives. But whilst the petrol does its work slowly, as in moving a car through a distance of, say, 50 miles in an hour or two, nitro-glycerine pushes away its surroundings in all directions to a relatively short distance in a fraction of a second. Blast, noise and the resultant picture of ruthless destruction all tempt the casual observer to suppose that work so quickly done is evidence of an exceptionally high concentration of energy in the explosive.

There are several ways in which chemical energy can be stored to form an explosive. For example, we can mix a combustible material like sugar with an oxygen-rich compound, such as potassium chlorate, from which much of the oxygen contents are easily set free to burn the sugar and thus form a large volume of hot gases. If, however, the mixture is to be explosive, as distinct from merely slowly burning, the ingredients must be finely powdered and well mixed. Thermite is not an explosive in its usual form. The two constituents, aluminium and iron oxide, are present as coarse granules and can therefore only interact so slowly that the reaction products have time to cool sufficiently for the iron to liquefy. On the other hand, a thermite mixture consisting of finely powdered and intimately mixed materials can be made to explode with violence, because the reaction products are then formed too quickly for appreciable heat losses to occur and the iron is obtained in the gaseous state.

It is not possible, however, to attain by mechanical mixing that perfect apposition of combustible and oxygen which is secured when both are suitably combined into a single chemical compound. But this combination is a peculiar one, in that the combustible and the oxygen are only loosely or indirectly associated in the molecule, usually through the intermediary of some relatively inert atom, such as nitrogen, as, for example, in ammonium nitrate,

$$\left.\begin{matrix}H\\H\\H\\H\end{matrix}\right\}\equiv N-O-N\begin{matrix}=O\\=O\end{matrix}$$

In this case the energy needed to strip the four hydrogen and two of the oxygen atoms from the nitrogen atoms to which they are attached is much less than that furnished by their subsequent combustion to steam. On explosion, this surplus energy appears in the form of heat carried by the steam, the volume of which is many times greater than that of the solid ammonium nitrate. And to this already great volume of hot steam is added the hot nitrous oxide gas into which the remainder of the molecule rearranges itself with evolution of further heat energy. The whole reaction can proceed at an extremely high rate; ammonium nitrate is therefore a powerful explosive.

The close approximation of combustible and oxidising atoms whose interaction leads to the formation of hot gases is not the only way of storing up chemical energy to form an explosive chemical compound. Any compound is a store of chemical energy if a rearrangement of its constituent atoms is possible which is attended by the evolution of heat; and if the rearrangement can occur swiftly with the formation of gaseous products, then the compound is an explosive. Thus ethane is not explosive, because energy is absorbed in any rearrangement of its atoms. On the other hand, ethylene can decompose into a mixture of solid carbon, molecular hydrogen and methane; and, thanks to the formation of the methane, the change as a whole is accompanied by evolution of heat. It has, indeed, been recently discovered that ethylene can be exploded when compressed to as little as 10 atmospheres. In contrast to ethylene, the dissociation of acetylene into soot (solid carbon) and molecular hydrogen liberates heat, and acetylene has long been recognised as an explosive gas, particularly when compressed. We can most conveniently effect this compression chemically, *i.e.*, by making use of some of the chemical energy stored in acetylene. Thus the hydrogen of acetylene is easily replaced by metals such as copper, silver and mercury. The resulting compounds are solids, so that their chemical energy is concentrated into a far

Detonation shock wave

Subsidiary shock waves set up by the blast

Blast

BLAST AND DETONATION SHOCK WAVES

smaller volume than in acetylene gas itself. These acetylides are violent explosives, which decompose into soot and a highly heated gas of metallic atoms. It is the resolution of the acetylene triple bond into the single bonds of soot which is the source of the heat energy set free on explosion.

There are other kinds of atomic arrangements which can serve as stores of easily released chemical energy. For example, although the dilute hydrogen peroxide of commerce is harmless, the pure liquid compound is explosive and decomposes readily into steam and molecular oxygen. Pure ozone, especially in the liquid or solid state, is an even more violent explosive. In each case the removal of an oxygen atom from the molecule requires the expenditure of much energy, but this is more than balanced by the enormous amount of heat evolved by the subsequent union of two such atoms to form a molecule of oxygen. Another atomic grouping where, on explosion, the main source of heat energy is furnished by the combination of like atoms to the molecular state is the triazo, $-N=N\equiv N$, group. Hydrazoic acid, $H-N=N\equiv N$, is an explosive liquid which readily forms a series of explosive metallic salts, of which lead azide is much used in the explosives industry.

An example of a class of compound in which the heat energy liberated on explosion results partly from the union of a combustible with an oxygen atom and partly from the formation of a molecule from like atoms is furnished by the fulminates. These are metallic salts of fulminic acid, $H-O-N\equiv C$, of which the best known is mercury fulminate, $Hg\begin{matrix}O-N\equiv C\\O-N\equiv C\end{matrix}$. On explosion, an atomic rearrangement takes place to yield as sole explosion products carbon monoxide, molecular nitrogen and mercury.

The prime function of an explosive is to do work at a high speed upon its surroundings. But these surroundings should be of our own choosing. This means that an explosive is useless if it cannot be manufactured, stored, transported and handled without undue risk. Some explosives, like impure nitro-glycerine or guncotton and many of the nitro-sugars, decompose, at first slowly; but this slow decomposition evolves heat and forms products which, by accelerating the reaction, may easily lead to a more rapid chemical change culminating in explosion. In other cases, the explosive itself may be so sensitive towards heat, shock, friction, contact with other materials or to some other influence that it must be regarded as too dangerous for use as an explosive. For example, compounds like nitrogen iodide and chloride, chlorazide, hydrazoic acid and liquid ozone are so extremely sensitive to shock or friction, and in some cases even to contact with traces of such a common adventitious impurity as grease, that they cannot be handled with safety except in the smallest amounts. Compared with such capricious compounds, the explosive mixtures used for tipping the domestic match are relatively insensitive, though still far too dangerous for use in bulk. Similarly, explosives like the acetylides, azides and fulminates can only be used in relatively small amounts and for special purposes, partly because of their sensitiveness to shock and friction and partly owing to the way in which they decompose. Nitro-glycerine is a much less sensitive compound either to shock or friction and was once transported and used as a bulk explosive; but the fact that it is a liquid introduces fresh elements of risk. Thus, accidentally spilt nitro-glycerine may easily be inadvertently subjected to harsh treatment. Also, it is liable to freeze, even in a temperate zone, and although the frozen material is less sensitive than the liquid, shaking may result in liquid nitro-glycerine imprisoned between the crystals being subjected to undue friction. Dry loose guncotton is also unsuitable for transport and use as a bulk explosive, though from the point of view of insensitiveness to shock and friction it ranks with nitro-glycerine. But for reasons connected with its bulky nature, proneness to form dust, sensitiveness to heat and liability to become electrically charged, its use is limited to a few special purposes. On the other hand, moist guncotton containing about 20 per cent. of water is a remarkably insensitive and useful explosive, especially for field demolition work.

It is, indeed, fortunate that most of the disadvantages of nitro-glycerine and guncotton as individual explosives disappear when they are incorporated together to form a solid plastic material. Thus blasting gelatine, a gelatinous plastic material obtained by dissolving a few per cent. of an incompletely nitrated cotton in nitro-glycerine, is less sensitive in virtually all respects than either of its ingredients and with reasonable precautions can be transported and handled with safety. It is one of the most powerful blasting explosives. Cordite is a horn-like plastic consisting of nitro-glycerine, guncotton and a few per cent. of petroleum jelly and is even less sensitive and safer to handle than blasting gelatine.

Although both these plastics are sufficiently insensitive for use in their respective spheres, *i.e.*, as blasting and propellant explosives respectively, they are still far too sensitive to shock and friction to be used as shell fillings, even if their properties were otherwise suited to this purpose. Owing to the high acceleration of a shell when travelling through the gun, an acceleration which may attain 20,000 times that due to the earth, the resulting "set-back" of its explosive contents gives rise to frictional and compression effects which can only be withstood by the most insensitive of explosives. Indeed, many of the explosives now used in shell fillings are so insensitive that they were not recognised as explosives until long after their discovery. Thus, picric acid, trinitro-toluene and other aromatic nitrate explosives are so "safe" that they may be found on the shelves of most chemical laboratories, in company with common chemicals such as potassium chlorate and ammonium nitrate, which are also capable of exploding with great violence. Ammonium nitrate is so remarkably insensitive that the fact that it is a potential explosive has sometimes been forgotten. The most disastrous explosion on record, from the point of view of both loss of life and material damage, occurred at Oppau in Germany in 1924, when a store of several thousand tons of ammonium nitrate exploded.

The sensitiveness of an explosive reflects its stability being a measure of the energy required to dislocate the arrangement of the atoms in its constituent molecules to such an extent that they prefer to relapse into a more stable configuration rather than return into their original positions. It is difficult, however, to obtain an absolute measure of this "least initiating energy," as it may be called, and in practice comparative tests must suffice. The results are sometimes conflicting; thus, nitro-glycerine is less sensitive to a hammer blow, but more sensitive to heat than lead azide. Hence, in comparing the sensitiveness of different explosives the nature of the test should be specified. Recent advances in our knowledge of crystal and molecular structure and of the nature of the chemical bond seem to offer a fair prospect of a better understanding of the energy relationships involved in initiating the explosive process, at least in those compounds which are

* Royal Institution of Great Britain Special Afternoon Lecture, February 11th, 1941.

† Professor of Applied Physical Chemistry, Imperial College, London.

crystalline and of simple molecular structure like, for example, the acetylides and the azides.

When an unconfined explosive is ignited by a flame, one is struck by the fact that, with certain few exceptions, explosives respond in one of two very different ways. Thus, match compositions, nitro-glycerine, guncottom, blasting gelatine, cordite and gunpowder burn quietly, some more quickly than others, with flames of characteristic colour. Picric acid, trinitrotoluene and the aromatic nitrates in general burn sluggishly with a sooty flame.

In striking contrast to the quiet burning of the above explosives is the behaviour of most of the acetylides, azides and the fulminates, which explode with great violence and set up intense shock waves when ignited. A closer examination reveals that this violent explosive process is preceded by a short period during which an initially slow rate of burning rapidly accelerates until the violently explosive stage is reached. In the case of burning, the energy needed to start decomposition in the hitherto unaffected portion of the explosive is handed on as heat from the burning zone to the adjacent unconsumed layer which is thus ignited, and so on from layer to layer throughout the explosive. On the other hand, the succeeding violently explosive stage is due to the setting up, as a result of a rapidly accelerating rate of burning, of a steep-fronted sound wave which travels through the explosive at a high uniform speed. The intensity of this wave is so great, approaching 150,000 kilos. per square centimetre, that the explosive at the wave front may be momentarily heated by adiabatic compression to a temperature of the order of 10,000 deg. Cent., so that the resulting explosion is propagated hand-in-hand with, and maintains the intensity of, the shock wave in its passage throughout the explosive. In traversing an inert medium, such as air, this intensity, of course, decreases rapidly ; nevertheless, the shock wave may still be capable of effecting explosion, even though attenuated by passage through a considerable air gap.

The process whereby explosion is effected by a shock wave is known as detonation. An explosive which, even when unconfined, burns rapidly to detonation may be called a detonant. The shock wave is usually known as the detonation wave. Its velocity lies between 3000 m. and 9000 m. per second and is related to that of sound in the same medium ; hence, each explosive has its own characteristic and constant rate of detonation. The detonants of which lead azide and mercury fulminate are the best-known representatives, play a vital *rôle* in the use of modern high explosives.

Ability to burn to detonation is not necessarily associated with a high degree of sensitiveness, nor is it evidence of high energy contents of the explosive, as is sometimes supposed. For example, both nitro-glycerine and cordite are roughly four times as powerful as mercury fulminate or lead azide. The explanation lies rather in the nature of the explosion products of the detonants, which are for the most part unable to dissociate appreciably, so that the chemical energy is transformed into heat in a single step instead of relatively slowly by a succession of stages.

The large class of explosives which burn quietly when unconfined may be further sub-divided into propellants and the so-called high explosives, according to their behaviour when ignited by flame in a strong enclosure. Propellants like gunpowder and cordite, merely burn. If it is non-porous and uniform in texture, like cordite, the propellant continues to burn from layer to layer at much the same uniform rate as when unenclosed, while porous substances, like gunpowder and the partially gelatinised smokeless powders, burn at a less uniform rate because the accumulating pressure forces hot gases into the pores and thus increases the rate of burning. Under similar conditions the high explosives, after a more or less prolonged period of burning of somewhat uncertain duration, eventually detonate.

As the name implies, the function of a propellant is to propel a selected object in a desired direction. The gun fulfils the dual purpose of guiding the projectile and confining the explosion gases so that they can expand only by driving apart the projectile and gun. Since their relative masses are very different, a high muzzle velocity of the projectile is balanced by a correspondingly slow recoil of the gun, which can be absorbed by a damping device or buffer. It is essential that the pressure of the explosion gases on the projectile should neither vary abruptly nor stress the gun unduly. At the same time, the maximum permissible pressure should be continually exerted on the projectile ; while, to avoid waste, the charge must be completely consumed before the projectile arrives at the muzzle. Since in a non-porous propellant combustion proceeds from the outermost layer inwards at a uniform rate, these demands can be met by a proper choice of the area-to-weight ratio of the explosive. For example, the cordite in a rifle cartridge consists of some fifty rods, each about as thick as a darning needle. In a big gun, however, where the projectile takes much longer to arrive at the muzzle, the rods may exceed 1in. in diameter.

An explosive which is liable to burn to detonation when confined, as in a gun, is quite useless as a propellant. Should detonation occur, the gas pressure suddenly rises with such rapidity that the projectile cannot move fast enough to keep it within bounds, and the gun bursts and shatters into many fragments. Such disasters, or "prematures," as they are sometimes called, were at one time by no means rare and were due to the use of propellants of an unreliable nature. The possibility of a premature occurring with a modern high-class propellant like cordite is so remote as to be negligible. This does not imply that a propellant cannot be made to detonate like any high explosive, but rather that it will not do so under the conditions of its use in a gun, where it will only burn.

In contrast to the propellants, the tasks which a high explosive has to perform are such as to require that its energy be made available in the shortest possible time. This can only be achieved by causing the explosive to detonate. If the gases were liberated slowly, as with a burning propellant, they would have time to open up weak places in the confining surroundings and then expand through these openings between the obstacles, instead of breaking up and flinging these away. For example, if the explosive charge in a shell were only to burn, then the slowly rising pressure would merely push out the fuse and the gases would escape through the fuse hole, leaving the shell intact. In the case of detonation, however, the gas pressure rises so quickly that there is no time for the inertia of the more easily removed obstacles to be overcome before the surroundings as a whole have been subjected to pressures which they cannot withstand. Hence when the shell filling detonates, the shell walls are broken up into fragments which are pushed outwards with high velocity by the intense pressure and blast of the expanding gases of detonation. Similarly, a slab of guncotton, even though unenclosed and merely laid on a steel rail, will sever this on being detonated, but would leave it unharmed if the explosive were merely to burn.

When the manufacture of nitro-glycerine had been established as a cheap commercial process, the problem of how to detonate it and thus unlock its energy to the best advantage became a pressing one. The solution was found in the discovery that the detonation wave in mercury fulminate placed in contact with nitro-glycerine could set up in it a fresh detonation wave with a velocity characteristic of this medium. In practice a small amount of detonant is packed into and partially fills a copper tube which is closed at one end and rather smaller than a cigarette. A length of slow-burning fuse or the ends of a pair of copper wires leading from a safe distance and bridged by a thin wire, which can be heated electrically and carries a bead of match composition, is fixed in the open end of the detonator, as it is called, which is then inserted in the nitro-glycerine or other high explosive. Once the detonant has been ignited by either of these devices it burns rapidly to detonation and thus in turn effects the detonation of the high explosive.

Whilst the more sensitive high explosives, such as blasting gelatine and dry guncotton, can be detonated without fail in this manner, others, like moist guncotton, the aromatic nitro-compounds—especially when cast or highly compressed—are uncertain in their response to the effects of even relatively large amounts of detonant, being often merely broken up into fragments and scattered. The difficulty is overcome by interposing between the detonator and the main insensitive explosive a few grammes of a high explosive which will respond with certainty to the action of the detonator and then pass on its own detonation wave to the main body of the insensitive explosive. This intermediate explosive is generally known as the "gaine."

The choice of a high explosive is governed by the kind of work it will have to do and by the treatment to which it is likely to be subjected before use. As shell fillings, only explosives which are highly insensitive to shock and friction can be used with safety ; otherwise detonation may occur before the fuse acts, or even before the shell leaves the gun barrel. Also, the gaine explosive and still more so the detonator contents must be so packed and supported in the main body of the shell filling that they, too, can withstand with certainty the rough handling of being fired from the gun. Finally, when the filling does its work the shell should break up into swiftly moving fragments of the most effective size and not be merely split into a few large pieces or completely pulverised. If nearly all the chemical energy became available immediately on detonation, as, for example, with lead azide, the shell would be broken up into powder and fragments too small for effective flight and the explosive is said to be "brisant" or shattering. On the other hand, if the chemical energy is transformed into heat by a succession of steps as, for example, where such easily dissociated molecules as steam and carbon dioxide form the bulk of the explosion products, the shell fragments are likely to be too large, an effect to which a low velocity of detonation may also indirectly contribute. Finally, in order that the fragments should move away with high velocity, or that the shell should do as much damage as possible on bursting after penetration into an obstacle, the explosive should have high chemical energy contents and yield only gaseous products. These requirements can best be met by mixing together two or more explosive compounds, a procedure which may have the additional advantage of enabling costs to be reduced. "Amatol," a high explosive consisting of a mixture of trinitrotoluene and ammonium nitrate, was introduced as a shell filling during the last war ; it was cheap and proved remarkably successful.

The high explosives used for blasting in quarrying and mining can be sufficiently sensitive to be detonated by a detonator without the added complication of an intermediate gaine, because the treatment which they receive in the course of transport, handling and in the final packing into the shothole drilled in the rock is mild compared with that which a shell filling has to withstand. Here again, the properties of the explosive must suit the work in hand. For example, in tunnelling through hard rock, a shattering and powerful explosive like blasting gelatine will serve best by breaking up the rock into small pieces easily handled for removal. On the other hand, for quarrying out large blocks of stone or in coal mining, where "small stuff" represents waste, explosives are used which are comparatively slow in their action. Owing to the danger of coal dust and fire-damp explosions, so-called "safety" explosives have been introduced for use in coal mining. These are slow-acting high explosives in which are incorporated substances like crystal soda, which, by absorbing heat, prevent the temperature of the explosion flame from rising sufficiently to ignite coal dust and methane-air mixtures.

The milestones marking the progress of the harnessing of explosives for the service of man are, as I see them, few but epoch-making. Long after the invention of gunpowder, the beginnings of which are veiled in antiquity, Howard in 1799 discovered mercury fulminate. About fifty years later Alfred Nobel succeeded in making nitro-glycerine, previously discovered by Sobrero, on a large scale, and followed this up by an astonishing series of inventions. Thus Nobel first used the mercury fulminate detonator to effect the detonation of nitro-glycerine, made dynamite by absorbing nitro-glycerine in diatomaceous earth and gelatinised nitro-glycerine with a low nitrated cotton. Another great pioneer and contemporary of Nobel was Sir Frederick Abel, who discovered that the secret of stabilising guncotton lay in shredding it so that the impurities trapped in the fibre cells could be washed out, and who by using acetone as a solvent worked nitro-glycerine, guncotton and mineral jelly into a plastic and thus obtained that remarkable propellant, cordite. Another of Abel's discoveries, that guncotton could be made extremely insensitive and safe to handle by moistening, was turned to good account by Edwin Brown's invention of the "gaine." Brown, as Abel's assistant, found that moist guncotton, which is so insensitive that it is only scattered by a detonator alone, responds without fail and detonates if the detonator is inserted into a small plug or "primer" of dry guncotton placed in contact with the moist material. Finally, we have had to wait for more than a century for an alternative to mercury fulminate, until at last Frank Miles' studies of the crystal structure of lead azide have revealed the causes of its erstwhile dangerous and erratic behaviour. To-day, lead azide bids fair to supersede mercury fulminate as a detonant.

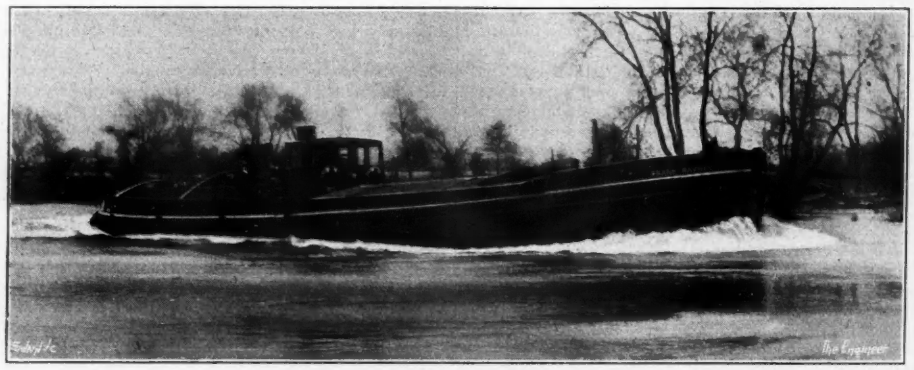
Some suppose that explosives have been a curse to humanity. But the truth is, as Buckle pointed out, that the good accruing to mankind from the invention of gunpowder far outweighs even the worst effects of its abuse. When gunpowder first came into effective use in warfare men were either credulous theologians or poorly disciplined and often arrogant and quarrelsome men-at-arms. Other professions were despised and the spirit of inquiry was suppressed. The cost and complexity of the new weapons resulted, however, in the growing restriction of the practice of war to a small professional class of disciplined soldiers and so set free the energy and minds of men for use in the pursuits of peace. Thus out of the invention of gunpowder the arts and sciences, and trade and exploration were reborn to flourish and awaken in man as never before a consciousness of his rights and a belief in his dignity which, sweeping away the feudal system, built up our civilisation.

Alfred Nobel was the founder of the modern explosives industry ; to him his blasting explosives were, like gunpowder, servants to humanity and, though he foresaw their exploitation in the conduct of warfare, he also realised clearly that their good and proper use must eventually prevail. Even in our generation the quantity of explosives used in quarrying, tunnelling, mining, agriculture and for other peaceful purposes has far exceeded their consumption by the military machine. It is true the vast increase in fire power and manœuvre which science and engineering have made possible to-day can for a time be abused to suppress liberty ; but not for long, and then, by its very cost and complexity, the new machine must eventually divert still more human energy to the arts of peace and freedom.

GLASS PROTECTION EXHIBITIONS.—A series of exhibitions illustrating the methods of protection of glass in houses, factories and shops, glass substitution and ventilation and obscuration in the black-out has been arranged simultaneously by the Ministry of Home Security at the following addresses :—(1) The Building Centre, 158, New Bond Street, London, W.1 ; (2) The Building Centre, 425, Sauchiehall Street, Glasgow, C.2 ; The Manchester Municipal School of Art, Cavendish Street, All Saints', Manchester, 15 ; (4) The Museum and Art Gallery, Queen's Road, Bristol. Exhibits from more than 150 firms will be shown in London, and all have been submitted to the Research and Experiments Department of the Ministry.

The Trent Motor Tug "Frank Rayner"

IN the accompanying drawing and engravings we illustrate the design and propelling machinery of the motor tug "Frank Rayner," which marks the latest addition to the fleet of the Trent Navigation Company, Ltd., and has recently entered its service. The new vessel has been appropriately named after Lieut.-Colonel Frank Rayner, D.S.O., T.D., in recognition of his work extending over more than half a century in furthering the interests of inland water transport, particularly those of the Trent Navigation Company," the foregoing words being inscribed on a brass plate fixed on the bridge of the tug.



MOTOR TUG "FRANK RAYNER"

The vessel was specially designed for towing work, but she is also able to carry 90 tons of cargo. Her builders were the Lincolnshire firm of Warren's New Holland Shipyard, Ltd., of New Holland, and the following are the principal particulars of the ship and her propelling machinery :—

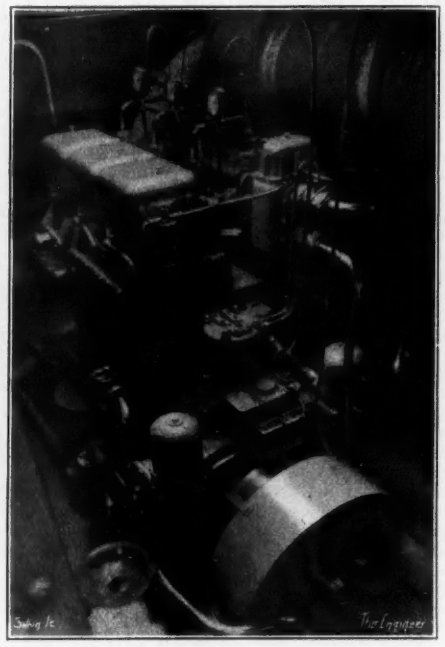
Length overall	82ft. 6in.
Breadth moulded	14ft. 6in.
Depth moulded	6ft.
Cargo carrying capacity	90 tons
Type of propelling machinery	Petter super-scavenge engine
Designed output	180 S.H.P.
Number of cylinders	Three
Cylinder bore	8½in.
Stroke	13in.
Propeller speed	500 r.p.m.

The hull is constructed to scantlings equal to Lloyd's requirements and all the materials used were tested. It will be noted that the compartments at the bow and the stern are arranged for the reception of water ballast, so that the draught may be increased, if required, when the vessel is being employed solely as a tug.

The drawings we reproduce show the lay-out of the ship and her propelling machinery, which comprises a three-cylinder super-scavenge Petter oil engine, having a designed output of 180 S.H.P. at 500 r.p.m. The unit is complete with reverse gear. The engine foundations are specially strengthened, and the accompanying engraving shows a view in the engine-room. A feature of the ship is the large clear hatchway with dimensions of 27ft. 6in. by 10ft. 4½in. Provision for draining the holds is made by the fitting of a series of 5in. cast iron pumps, shown on the plan. Forward of the funnel is a wheel house of comfortable design, and the deck fittings include the usual arrangement of bollards and spring timbers. The towing hook is placed on the engine-room casing immediately behind the funnel, and there are two tow rails, one on the after part of the engine-room casing and the other right aft above the rudder gear.

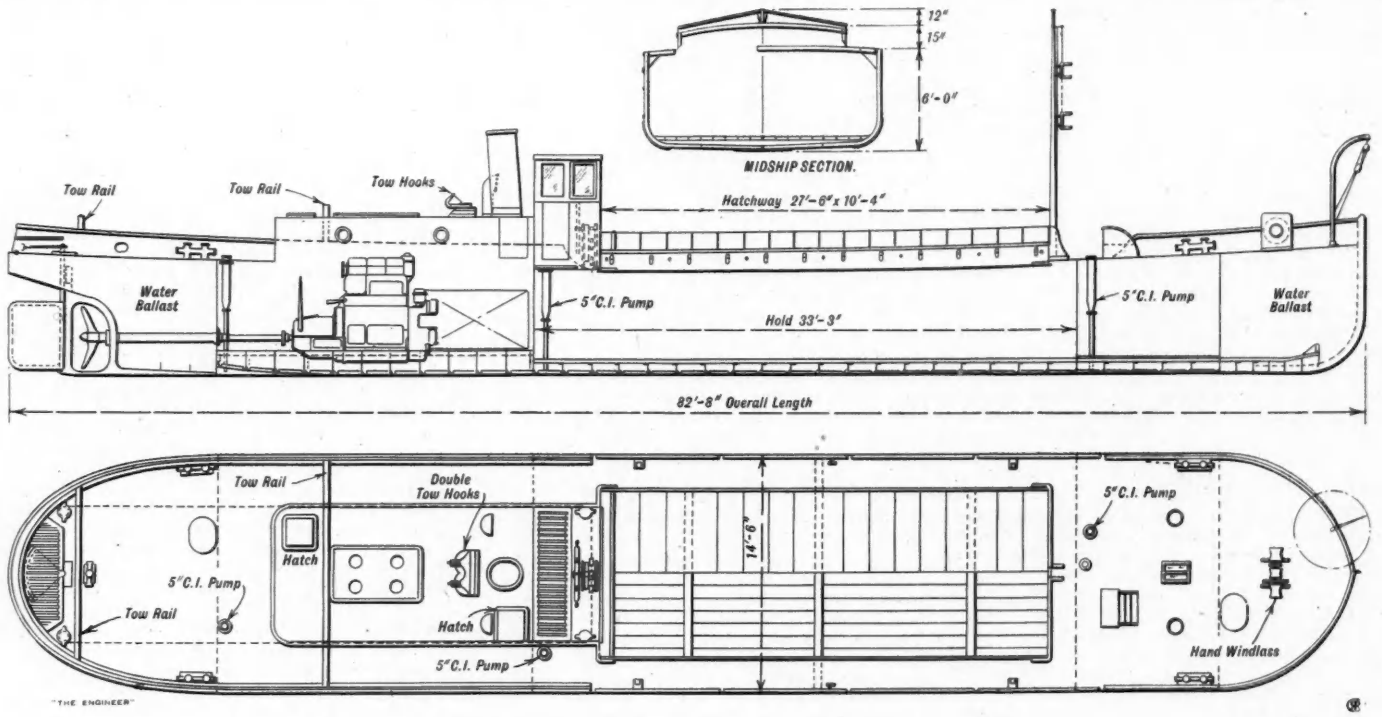
In service it has been shown that the engine is particularly suitable for river traffic, and its flexibility and comparatively slow speed of running give manœuvring ability in restricted waterways. Another Petter-engined ship, the motor vessel "Tees," also belonging to the Trent Navigation Company, has been operating satisfactorily in the company's service for nine years. In addition to the "Frank Rayner," there have also been constructed for the company twelve modern steel lighters, which in service have proved ideal for special traffic. All these vessels have been built under the supervision and to the inspection of Mr. J. T. Evans, the engineer and manager of the Trent Navigation Company.

The naming of the ship after Lieut.-Colonel Frank Rayner is a fitting tribute to his work for the company. He joined it as an engineer in 1887 and in 1896 he was appointed the chief engineer and manager of the company. In 1898 he became director and consulting engineer. Apart from his work in connection with the Trent Navigation Company, Colonel Rayner has devoted much time to the study of the problems of inland water traffic, and is an authority on this aspect of transport. He is a Past-President of the Canal Association, a member of the Traffic Advisory Council and a past member of Council of the Institute of Transport. He has given evidence on inland waterways to several Royal Commissions, and has contributed many papers on that subject to various learned societies. During his long term of service with the Trent Navigation Company Colonel Rayner has seen a great change in the navigation of the River Trent. In less than fifteen years a sum in excess of £600,000 has been spent on the improvement of the river's navigation, and as a result the time of transit from Hull to Nottingham has been reduced to one day, while Nottingham has now become an inland port of very considerable national importance. The company now possesses large modern warehouses, between them capable of storing something like 50,000 tons of merchandise. They are all equipped with modern handling gear, designed to facilitate the speedy loading and unloading of goods. The company's motor fleet operates for each of the warehouse centres and any quantity out of a given consignment can be delivered to order without delay. The collection and delivery services cover a radius of 50 miles.



VIEW IN ENGINE ROOM

Under wartime conditions the Trent has proved a valuable asset in Midland transport and is co-operating with road and rail transport to meet the services so vital to the national interest. In this work the motor vessel "Frank Rayner" is taking an important part.



ARRANGEMENT OF MOTOR TUG "FRANK RAYNER"

CARBORUNDUM'S JUBILEE.—This year marks the fiftieth anniversary of the discovery of silicon carbide, the first commercial artificial abrasive. Until 1891 the only abrasives were natural ones, so irregular in composition as to make accuracy on a production basis wellnigh impossible. Dr. E. G. Acheson, while experimenting with an electric current passed through a mixture of clay and coke, discovered adhering to the carbon electrode crystals which would not only cut glass, but would scratch diamond. The first production plant was built at Monongahela City, Pa., but the greatly lower cost of the necessary electric power at Niagara Falls brought about the move, in 1895, to the present works.

Sixty Years Ago

THE PARSONS HIGH-SPEED MOTOR

IN our issue of May 27th, 1881, we reported that the Hon. R. C. Parsons had invented a new engine, which was being manufactured by Kitson and Co., of Leeds. We described the engine as consisting externally of a closed cylindrical vessel from one side of which the end of the crankshaft protruded. Inside this vessel four single-acting cylinders were arranged radially round the crankshaft, the centre line of which was normal to the plane in which the cylinders lay. The speed of the reciprocating parts was moderate, and was not allowed to exceed the number of reciprocations corresponding to 450 r.p.m. The number of revolutions of the crankshaft was, however, doubled by causing the casting forming the four cylinders to rotate in the same direction as the crankshaft. The cylinder casting was carefully balanced, and it was claimed that the high speed of 900 r.p.m. was obtained with no more noise, shake, wear, or tear than would be shown by an ordinary engine of similar power running at 450 r.p.m. The object of the enclosing vessel round the cylinders was, we explained, to collect the exhaust steam, to act as a dust excluder and safety guard, and to preserve the cylinders at a temperature of at least 212 deg. Fah. A second new feature of the engine was stated to consist of a small pump which supplied lubricant continuously to the moving parts of the engine. . . . This engine is usually and, it would seem, correctly attributed to the Hon. C. A. Parsons. Richard Clere Parsons, born 1851, was the third son of the third Earl of Rosse and therefore Charles' elder brother. He was a partner in Kitson and Co. at the time with which our note is concerned.

BRITISH STANDARDS INSTITUTION

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 3d. post free, unless otherwise stated.

INDUSTRIAL CIRCUIT BREAKERS

No. 936—1941. It was stated in the Foreword to the 1937 edition of B.S. 116, Oil Circuit Breakers, that pending the issue of a specification for industrial circuit breakers, B.S. 116—1929 could be applied to such circuit breakers for voltages below 3·3 kW. The 1929 edition of B.S. 116, however, was very incomplete as regards the tests to verify the rating. This new specification applies to single-phase and three-phase breakers having breaking capacities up to 44,000 amperes and intended for use in those electrically remote parts of the system where marked asymmetry in the short-circuit current cannot occur, and where the restriking voltage conditions are not severe. The general structure of the specification closely follows that of B.S. 116—1937, there being sections on rating and marking, temperature rise, routine tests, type tests, service conditions, care, and maintenance. Price 3s. 10d. post free.

CAST BRASS BARS AND FORGINGS

No. 944—1941. This War Emergency British Standard is being issued at the request of the Ministry of Supply. It is intended to provide material which may for some purposes be used as an alternative to rolled or extruded brass bars as covered by B.S. 218 in order to relieve the pressure of the demand for such bars. The specification has accordingly been modelled along the lines of B.S. 218 and includes the same chemical composition, but with an appropriate modification to the mechanical testing requirements.

SUPPLY OF SLIP GAUGES DURING THE WAR

In order to facilitate the manufacture of slip gauges and so augment their supply during the war, the British Standards Institution has, on the recommendation of the Ministry of Supply, issued certain amendments to the British Standard No. 888, Slip (or Block) Gauges. These amendments provide for a slight relaxation of the permissible errors in length of "workshop" gauges and the introduction of a new grade to be known as "workshop B" gauges. From now onwards, "calibration" and "inspection" grade slip gauges will only be supplied to a certificate issued by the Ministry of Supply. Inspection departments should accordingly order "workshop A" slip gauges for applications where "inspection" grade gauges were formerly used, and "workshop B" gauges should be ordered for use in the shops. Copies of this amendment to the B.S. 888 may be obtained gratis by sending a stamped addressed envelope to the Institution.

ORDNANCE WORKS IN INDIA.—Under what is known as the report of the Chatfield Committee, plans have been worked out to manufacture in India modern types of armament, including 25-pounder guns and ammunition, aircraft bombs, light machine guns and loose barrels for the 3·7in. anti-aircraft guns. As early as the spring of 1940 the ordnance factories already giving good output were notified that an increased production of certain types of munitions over and above their planned programme was required and arrangements were therefore made to place orders with the civil trade for certain munition components. As a result of these arrangements the trade is now producing large quantities of empty shell, components of various kinds, hand grenades, &c., and the output will increase in the future.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer

New Steel Control Directions

The Ministry of Supply has issued two Directions (No. 3 and No. 4) under the Control of Iron and Steel (No. 8) Order, 1940. Direction No. 3 deals with iron castings, and under paragraph 1 maximum prices for iron castings in the form of rain water and soil goods, gutters and connections, *i.e.*, what is usually known as builders' ironwork, are increased to 21 per cent. above the basis prices in the deposited Schedules; an increase of 2½ per cent. on those basis prices as compared with the prices previously ruling. This advance is based on increases in the cost of wages and fuel. Paragraph 2 of the Direction restricts to half a hundredweight, or £10 in value, the maximum quantity of iron castings which any person may buy without licence in any week. The previous limit was 5 cwt., or £10, and this further restriction arises from the necessity of conserving supplies of iron. This Direction came into force on May 16th. Direction No. 4, which came into operation on May 17th, provides for an increase in the maximum price of hematite iron ore mined in Cumberland, Lancashire and Glamorgan from £1 6s. per ton to £1 7s. 6d. per ton for a standard grade, with a sliding scale based on iron and silica contents. There is a corresponding increase of 1s. 6d. per ton in the special grade of this ore used in steel furnaces. The new price takes account of the increased costs incurred in the production of the ore. Copies of these Directions may be obtained from H.M. Stationery Office, York House, Kingsway, W.C.2, or through any bookseller, price 1d.

The Pig Iron Market

The foundry pig iron market in this country is somewhat patchy. The light castings foundries report some improvement in the sales of their products, but their consumption remains on a restricted scale. Further development of demand in this section must depend largely on the buying policy of Government Departments. On the other hand, there is a good demand from the heavy engineering foundries, which are busy on big castings for essential war work, such as the manufacture of machine tools, and it is not always easy to supply these consumers with exactly the description of pig iron they need. Some ingenuity is being exercised in the use of unusual grades, which are in comparatively plentiful supply. Steel-making irons remain in excellent request. There is heavy pressure for hematite iron which producers are in many cases finding it difficult to meet, particularly as some furnaces are reported to have gone over to the manufacture of refined irons for special reasons. Home supplies of hematite are being helped by certain withdrawals from the stocks of imported material accumulated by the Control for such an emergency. Naturally the distribution and consumption of this description are being most rigorously supervised, and no licences are being issued by the Control unless the need is imperative. Generally speaking, the British blast-furnaces are working at an extremely high rate of pressure, although the necessity for increasing the output of steel further, if possible, is being kept well in view, owing to the importance of conserving shipping space, so that there may be no check in the arrival of American pig iron into this country. The pig iron supply position can also be safeguarded by cutting down still further consumption for civilian needs.

The Midlands and South Wales

In the Midlands, although there was recently some expansion in the local demand for foundry iron, conditions have again become quieter. The fact is, of course, that the light castings foundries are greatly dependent on the house and building construction industry, and with this outlet closed since the war began, there has been only a restricted call for light castings. Such Government work as has come forward has been totally inadequate to make the light foundries really busy. On the other hand, the demand for heavy castings appears to be expanding continuously, and this swells the aggregate demand for foundry pig iron grades. Low-phosphorus irons are in short supply, but consumers are able to call on high-phosphorus and refined irons to make good the deficiency. Supplies of semis for the re-rollers seem to be sufficient when eked out by imported material, and the mills are well employed, concentrated particularly on small bars, sheets and strip. It is believed that steps are being taken to increase the home output of semis still further in order to save shipping space. The demand for bar iron has become a little quieter during the past week. Many steel masters are complaining of a shortage of scrap iron and steel, but, nevertheless, the industry continues to operate at a high rate. There has been a moderate improvement in the heavy structural steel department, but the position in the Midlands is comparatively quiet. On the other hand, plates, sheets, tubes, light structural steel, and special steels for the munitions and aircraft industry are under heavy buying pressure. . . . In South Wales the rate of employment in the iron and steel industry is well maintained. There is an excellent demand for Welsh hematite and basic pig iron, and the large call for billets has to be partly satisfied out of imports. The pressure for sheet and tin-plate bars remains intense.

The North-East Coast and Yorkshire

Despite official contradictions that there is any shortage of scrap iron and steel, many steel masters in the North-East Coast region are complaining that they are not receiving enough of this material. The Control is meanwhile supervising the distribution of steel to consumers with increasing severity. One recent result of this has been that supplies to priority users have been accelerated, but, on the other hand, non-essential industries are obtaining less steel than ever. Supplies of semis, both British and American, are adequate, and the rolling mills are busy turning out big tonnages of black and galvanised sheets and light sections, for which there is heavy request. The heavy rolling mills making large structural shapes appear to be somewhat better off for business than they were, but some of them can still offer comparatively early delivery. Owing to the completion of much of the big constructional work upon which the Government embarked some considerable time ago, it is to be assumed that no early widespread revival in this department is to be anticipated. Plates and other shipbuilding steel are going into consumption in enormous quantities as a result of the boom in the shipyards. Colliery steel is also a good market. In Yorkshire the demand for special steels, mainly for armaments, is intense, and output is being increased. The rolling mills and forges are busy. Plates remain an extremely busy market, but delivery delays in the case of structural steel have become shorter.

Copper and Tin

No appreciable change can be reported in the copper position in this country. The demand remains at a high level, and is almost entirely for metal for Government requirements. The necessary raw material is being supplied regularly by the Control. The use of secondary metal from copper and brass scrap is now much better organised than was the case in the early months of the war. As a result of the heavy demand for extruded brass bars the British Standards Institution, at the request of the Ministry of Supply, is to issue a war emergency standard for cast brass bars suitable for forging, as an alternative to rolled or extruded bars. Production at the various processing plants is maintained at maximum levels. In the United States firm and active conditions rule. The April statistics of the Copper Institute give the production of blister copper as 88,271 short tons, against 85,643 tons in March. Refined production was appreciably lower at 88,659 tons, compared with 95,322 tons the previous month. Domestic deliveries fell to 80,722 tons from 103,132 in March, but deliveries of foreign copper rose to 42,985 tons from 31,201 tons. The stocks of refined copper were higher at 97,761 tons, compared with 89,873 tons a month previously. . . . The tin market has provided no point of outstanding interest during the past week. The meeting of the International Tin Committee in London on May 15th was apparently of a routine nature in connection with drafting the new restriction agreement, and no official communique was issued. It is reported, however, that at the meeting the thorny question of standard tonnages was left open, replies not yet having been received to the Committee's recent suggestions involving reduction in the standard tonnage of Bolivia, and an increase in the case of Malaya and the Dutch East Indies. Conditions in the American market have continued active. The Navy Department has made further purchases and, in addition, there has been a fair commercial interest. In London trading has been quiet at times and the tendency of cash prices last week was easier. The Metals Reserve Company in America has definitely increased the quantity of tin it is prepared to purchase at 50c. per pound, c.i.f. and is apparently prepared to take an additional 37,500 tons over the remainder of this year, and probably another 37,500 tons in the first half of 1942, making the total purchasing programme 150,000 tons.

Lead and Spelter

The demand for Government purposes continues to come chiefly from the cable and battery industries, although with some reorganisation of the building industry there may be a limited expansion in the use of pipes and sheets and lead paints. Among the less important uses solder continues an active market, and consumption in this direction is higher than in pre-war days. The supply of lead scrap is less abundant than some time ago, and available scrap is readily absorbed by the secondary smelters and put back on the market again. The American lead market remains firm, and with Mexican metal to fall back on when domestic supplies are short, consumers appear to have no particular difficulty in securing adequate supplies. . . . The demand for spelter remains high, with enough metal forthcoming to satisfy urgent national needs. Whilst the more obvious Government requirements of spelter are for high-grade metal in brassmaking and zinc alloy die casting, a substantial quantity of galvanised sheets is being consumed for Government purposes, and is absorbing available supplies of g.o.b. metal. Although there is plenty of metal for essential purposes, comparatively little is left available for allocation to industrial consumers for export. In the United States no material improvement is yet discernible in the supply situation. No difficulty has been encountered so far as zinc concentrates are concerned, but the bottle neck of smelter capacity has not been widened sufficiently by new plant for all urgent requirements to be comfortably met. New plant, however, is gradually nearing completion, and output is expected to go up before long.

World Steel Production

Recent speeches by American industrial leaders have laid stress on the much larger steel-producing capacity of the democracies when compared with that of the Axis Powers. According to the Metal Information Bureau, Germany can produce annually 30,000,000 tons of steel, France 10,000,000 tons, Czechoslovakia 1,500,000 tons, Belgium 4,000,000 tons, Luxembourg 2,000,000 tons, Poland 1,500,000 tons, Japan 10,000,000 tons, and Italy 2,500,000 tons. This gives a total annual output for the Axis countries of 61,500,000 tons, a figure which is exceeded by the steel-making capacity of the United States alone, namely, 85,000,000 tons, to which has to be added the production of Great Britain 15,000,000 tons, Australia 1,300,000 tons, India 1,000,000 tons, and South Africa 200,000 tons, a total of 102,500,000 tons for the democracies. Russia's steel-making capacity is somewhere in the neighbourhood of 20,000,000 tons annually, but she must be regarded as sitting on the fence at the present time. Large tonnages of Americah iron and steel are arriving in Great Britain, and these are likely to expand further in the near future. Under an agreement just concluded between France and Germany, the latter is to permit the moving of steel from occupied France into unoccupied France, where there is a virtual famine in steel.

Notes and Memoranda

Rail and Road

TIME-TABLE INCONSISTENCIES.—Northern Ireland has fallen into line with the May Summer Time. Eire has not, and Irish time-tables provide the amusing record that trains from Dublin to Belfast, 113 miles, apparently occupy 3½ to 4 hours; whereas those in the reverse direction make the journey in 100 minutes.

SAND-BLASTING BAYONETS.—In the Fort Rouge, Man., shops of Canadian National Railways plans have been elaborated for the sand-blasting of bayonets with the existing plant. The bayonets are arranged on a flat platform so that the greatest number can be treated at once, provision being made to prevent any overlapping during the process.

JAMALPUR BRIDGE.—Indian exchanges report the completion of the Jamalpur Bridge at Ahmedabad. It has a carriageway 4100ft. long, the overall length with the approaches being 7000ft. The road is 32ft. wide between kerbs on the bridge itself and 8ft. wider on the approaches. For effective lighting a staggered arrangement of units with 250-watt Osira high-pressure mercury vapour lamps, 140ft. apart, was chosen for the entire length.

LINKING UP IN BURMA.—The British Government is to finance the construction of an extension of the Burma railways from Lashio to the China frontier near Kunlong, and thus link up the railway systems of both countries. The work will make possible the completion of the Yunnan and Burma and Yunnan and Szechwan railways, two lines which have a common point at Kunming, the capital of Yunnan. Rapid construction, in so far as earthwork and masonry are concerned, has been made, but progress is held up for lack of imported materials.

PEAT FUEL FOR MOTOR-CARS.—A successful trial run of 7457 miles by a motor-car equipped with a gas generator using peat as fuel has been carried out by the Peat Institute of the Academy of Sciences of Belorussia. Designers and scientists of the Institute worked for a long time on the development of a suitable gas generator, but the stumbling block was the high ash content of peat. This obstacle was finally overcome by the designing of a special swinging grate. An ordinary gas generator, operating on wood, can be converted to the use of peat by installing the grating. The consumption of peat is stated to be less than 2 lb. per mile.

MOVING A WATER TANK.—The Canadian National Railways are engaged in reorganising the water tank service at their stations and junctions, and a major achievement of the scheme was the moving without dismantling of a 41,600 Imperial gallon steel tank from Ascalon, out to Kilrush, 13 miles away in a single day. The tank was lifted on to a bogey truck by means of two cranes arranged at each end, and then it was drawn and pushed to its destination by locomotives. Special precautions had to be taken to maintain the vertical position in narrow gaps and over curved switchways. The structure, which was 21ft. diameter, weighed 50 tons, and its height on the bogey truck was 69ft.

A TALL TALE.—An example of the unusual incident as it happens on "the other side" comes from the Canadian National Railways. An engine driver had his attention drawn by his fireman to something on the track, but they did not feel anything blow. However, a snow plume was set up and continued for three-quarters of a mile. Then the driver stopped and found he had scooped up a big bull moose. The animal was wedged between the draw-bar head and the pilot, with its legs in the air. The driver backed his locomotive and freed the moose, which gathered himself together, found he was uninjured, and loped up a side hill "as though nothing had happened, and not even thanking us for the ride."

RAILWAY REPAIRS.—In an interesting article on temporary repairs after air raids have damaged bridges and the like, the *Railway Gazette* points out that for temporary structures to carry the traffic while the permanent work is being restored, rolled steel joists of I section have been used to span gaps, and where abutments or piers have been rendered unsafe, they have been effectively replaced for the time being by steel scaffolding of ingenious design, which can be rapidly assembled on the Meccano principle to suit varying circumstances. A good deal of ingenuity and skill have been displayed in the employment of these and other devices for re-establishing traffic temporarily, pending the completion of permanent repairs.

Air and Water

DEVICE TO AID PARACHUTISTS.—A new device for recording every phase of parachute jumps was successfully tested in Moscow recently. Baling out at an altitude of 4921ft., with the apparatus fastened to their belts, two flyers came down with a complete record of their jumps, even to the oscillation caused by the wind. The apparatus is constructed on the principle of the barograph. A curved line described on a ribbon records the height of the jump, how many seconds elapsed in the free drop, when the parachute opened, and how the subsequent descent proceeded.

CONTROL OF SHIPPING.—The Minister of War Transport has made an Order under the Defence Regulations entitled the Use and Hire of Ships (Control) Order, 1941, which came into force on May 22nd. The provisions contained in the Order are as follows:—No person shall, except with the authority in writing of the Minister or a person authorised in that behalf by the Minister and subject to the compliance with any conditions imposed by the Minister or other person giving authority, enter into or offer to enter into an agreement for the use or hire of any ship to which this Order applies or for the carriage of goods in such a ship. This Order shall apply to every ship, not being a fishing boat or a Government ship or a licensed ship, having a gross tonnage of 1600 tons or more. In this Order the following expressions have the meanings assigned to them, that is to say:—"Ship" has the same meaning as in the Merchant Shipping Act, 1894; "fishing boat" means a vessel of any description for the time being employed in fishing or in the sea fishing service; "Government ship" means a ship which (*a*) belongs to His Majesty or is held by any person on behalf of or for the benefit of the Crown, or (*b*) is at the disposal of His Majesty whether by virtue of the exercise of any power of requisitioning the ship or otherwise, or (*c*) is under charter to or for His Majesty; "licensed ship" means a ship in respect of which there is for the time being in force a licence granted in pursuance of an Order made under Regulation 46 of the Defence (General) Regulations, 1939. Copies of the Order will shortly be obtainable through H.M. Stationery Office and from booksellers in the usual way.

AN ALL-WELDED TANKER.—A shipbuilding record was claimed by the sailing of the tanker "E. H. Blum" one day less than six months after her keel was laid in the Chester yards of the Sun Shipbuilding and Dry Dock Company. Built for the Atlantic Refining Company, the "E. H. Blum" is of all-welded construction and is 544ft. length overall, with a cargo capacity of 154,000 barrels. According to the *Shipping World*, the construction time was a record for an all-welded ship of this size. The tanker is propelled by turbo-electric machinery of 5000 H.P. at a service speed of 13¼ knots.

TO FURTHER AIR RESEARCH.—The General Electric Company of America and one other concern are backing a research project designed to extend modern knowledge of aerodynamics as applied to power development. On the summit of Grandpa's Knob in the Green Mountain, near Rutland, Vt., a wind turbine propeller is under construction which will have a length of 175ft. and weighs 20 tons. The propeller and power unit, having a total weight of 75 tons, is being installed on a 110ft. tower. It is hoped to have the unit in operation this summer. This wind turbine, which is expected to develop 1000 kW, will be used to determine the feasibility of applying modern aerodynamic knowledge to the conversion of wind power into electric energy. If successful the acquired experience will be used as the basis for the design of other wind turbines.

Miscellanea

CHINA CLAY IN INDIA.—The paper industry in the Mysore area has learned with satisfaction that extensive deposits of a good quality of china clay have been discovered in the Malnad District of that State.

NEW DELHI BROADCASTING HOUSE.—The Standing Finance Committee of the Indian Government has approved the expenditure of Rs. 9,33,000 for the construction of a broadcasting house in New Delhi.

A "CYCLOTRON" FOR CALCUTTA.—The Senate of the University of Calcutta has accepted the offer of Rs. 60,000 by the Board of Trustees, Sir Dorabji Tata Charities Trust, for the purchase of a "Cyclotron." It will be installed in a newly constructed building in the grounds of the Science College of the University in Upper Circular Road, and will be the first instrument of its kind, not only in India, but also in Asia.

CEMENT FOR IRAK.—According to a Canadian paper, the plant for the first cement works to be built in Iraq has been despatched from a British works. It includes machinery for crushing the limestone, mills for grinding the limestone and clay, a rotary kiln 300ft. long for burning the raw materials, another large mill for making finished cement, and a machine automatically to pack the product in paper sacks. The works will turn out 250 tons of cement a day.

TO STRAIGHTEN ARMOUR PLATE.—An American engineering concern has designed a press especially adapted to straighten armour plate which under heat treatment becomes warped and must be brought back to shape. The new tool is big enough to deal with plate 2½in. thick. One hundred or several hundred strokes may be required as the condition of the plate demands. The press runs at from twenty to forty strokes per minute, depending upon plate thickness.

DIESEL OIL SUBSTITUTES.—A bulletin on the use of Indian vegetable oils as fuels for C.I. engines is the result of the Industrial Research Bureau's investigations. Many of the commoner Indian vegetable oils can be used satisfactorily as engine fuel in place of mineral diesel oil. The investigations, which lasted three years, were made at the Government Test House, Alipore, Calcutta. It is claimed that substitution will entail hardly any alterations in the ordinary C.I. engines.

THE PETSAMO NICKEL MINES.—The negotiations going on in Moscow between Germany and other "interested parties" on the future working of the Petsamo nickel mines in North Finland do not make much progress. The concession was originally granted to the Mond Nickel Company. During the Finno-Russian war the mines were damaged, but, it is believed, have since been restarted. German interest in a settlement is natural, as Petsamo provides a means of supplementing her nickel supplies.

HIGH-GRADE COKE FROM LOW-GRADE COAL.—Soviet scientists are working out a new method for the industrial production of high-grade coke for smelting purposes from low-grade coal. A commission, headed by Professor M. A. Pavlov, has been carrying out experiments during the last two years at the Magnitogorsk Iron and Steel Works in the Urals with low-grade coal obtained from the deposits in the eastern and southern parts of the Soviet Union. This work was undertaken with the aim of extending the raw material base of the Soviet coke and chemical industry and improving the quality of coke for blast-furnaces. The Soviet Union has vast reserves of low-grade coal. Using data obtained by this commission, scientists of the Fuel Institute of the Academy of Sciences of the U.S.S.R. have designed an apparatus for determining the behaviour of coke in the blast-furnace, and have worked out a new system for rating coke. The apparatus, it is claimed, also makes it possible to control the technological régime during the process of smelting, to increase the productivity of blast-furnaces and to improve the quality of coke.

TUNGSTEN DISCOVERY IN AMERICA.—A high-grade deposit of tungsten ore has been discovered by engineers of the United States Bureau of Mines and geologists of the Geological Survey. The ore was found in the Yellow Pine District, Valley County, Idaho, a district well known for its antimonial gold ores, but not previously known to contain tungsten ores. The maximum dimensions of the ore deposit have not yet been determined, but sufficient information has already been secured to indicate that the discovery may be one of great importance.

STANDARDISED TOOL STEEL.—The American Standards Association is paying close attention to the standardisation and classification of tool steels used in the production of tools, fixtures and gauges. The work has been entrusted to a committee of representatives of leading engineering societies as well as governmental bureaux under the sponsorship of the American Society of Tool Engineers. It will attempt to do for the steels indicated what already has been done on general steel types, permitting purchasers of tool steels to specify the exact type of steel desired for any given purpose.

Personal and Business

THE Institute of British Foundrymen has announced that the E. J. Fox Gold Medal for 1941 is to be awarded to Mr. Percy Pritchard.

MR. R. W. AYERS has been appointed general manager of Sciaky Electric Welding Machines, Ltd. Mr. Ayers has been responsible for the sales side of the company's activities for a number of years.

WE record with regret the death, on May 19th, of Sir Thomas Williams, a director of the London, Midland and Scottish Railway Company. He joined the London and North-Western Railway in 1876 and became general manager of that company in 1919.

WE record with regret the death of Sir Bertram Fox Hayes, former Commodore of the White Star Line fleet, which took place at Crosby, Liverpool, on May 15th. He was seventy-six years of age, and last year was appointed Master of the Honourable Company of Master Mariners.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Scientific Workers

Saturday and Sunday, May 24th and 25th.—Imperial Hotel, Temple Street, Birmingham, 2. Annual Council meeting. 2.15 p.m. (Saturday) and 10 a.m. (Sunday).

Chartered Surveyors' Institution

Monday, May 26th.—12, Great George Street, Westminster, S.W.1. Annual general meeting. 5 p.m.

Incorporated Municipal Electrical Association

Thursday, June 12th.—Clifton Picture House, Clifton, York. General meeting. 11 a.m.

Institute of Metals

Wednesday, May 28th.—New Clarendon Laboratory, Parks Road, Oxford. May Lecture, "The Significance of Low-temperature Research," F. Simon. 3.30 p.m.

Institution of Automobile Engineers

Tuesday, May 27th.—12, Hobart Place, S.W.1. "Automobile Research," W. A. Tookey and E. Giffen. 6.30 p.m.

Institution of Electrical Engineers

Monday, May 26th.—Savoy Place, Victoria Embankment, W.C.2. Discussion, "Looking Forward," to be opened by J. R. Beard. 6.30 p.m.

Friday, June 6th.—METER AND INSTRUMENT SECTION: Waldorf Hotel, Aldwych, W.C.2. Informal luncheon. 12.40 for 1 p.m.

Institution of Mechanical Engineers

To-day, May 23rd.—Storey's Gate, Westminster, S.W.1. "Railway Refrigeration Problems," F. C. Johansen. 6 p.m.

CATALOGUES

COPES REGULATORS, Ltd., 28, High Street, High Wycombe, Bucks.—Booklet on the "Flowmatic" dual control regulator.

A. REYROLLE AND CO., Ltd., Hebburn-on-Tyne.—Pamphlet No. 1056, describing type "G A 4" flameproof air break switchgear.

S. S. WHITE COMPANY OF GREAT BRITAIN, Ltd., Britannia Works, Saint Pancras Way, N.W.1.—Booklet on flexible remote control.

SELSON MACHINE TOOL COMPANY, Ltd., Abbey House, Victoria Street, S.W.1.—Pamphlet on the "H. and G." general-purpose die head.

AVIATION DEVELOPMENTS, Ltd., Woodfield Road, Welwyn Garden City, Herts.—Illustrated booklet describing the Chobert system of riveting.

BRITISH INSULATED CABLES, Ltd., Prescot, Lancs.—General catalogue M.112, and catalogues on cables and accessories for collieries and cut-outs of distinction.

MALLORY METALLURGICAL PRODUCTS, Ltd., 78, Hatton Garden, E.C.1.—Booklet dealing with high-strength, high-conductivity copper alloys in cast form.

BUDENBERG GAUGE COMPANY, Ltd., Broadheath, near Manchester.—Leaflets dealing with "Durham" and "Timperley" recording pressure gauges and thermometers.

WALKER, CROSWELLER AND CO., Ltd., Whaddon Works, Cheltenham, Glos.—Leaflets on the Leonard thermostatic water mixing valves and steam and water mixers.